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RICHEST ALCHEMY

THE cover illustration this month shows part of the gas-separation area of an olefine plant. This is the latest and largest of three such plants in the North of England. The three plants together consume well over half a million tons/year of light naphtha feedstock and have a combined capacity for ethylene, their chief product, of almost 140000 tons/year. The Foreword on p. 711 discusses the role of the electrical engineer in the chemical industry

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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RICHEST ALCHEMY

MANY years of experience in recruiting, training and the subsequent moving into jobs of young engineers in the chemical and allied processing industries have shown how few young men seeking careers as chartered electrical engineers have any idea that the jobs available in the chemical industry compare favourably in challenge, intellectual interest, variety and reward with those to be had in the electrical manufacturing and electricity supply industries. The commonly held opinion that most electrical engineers in the chemical industry are necessarily mainly engaged in routine maintenance of the electrical and instrument installations is completely false, and in fact there are more careers available in research and development, design, erection and operation, as well as many openings in chemical-plant management, work study, the commercial and personnel fields, and all the way up to higher management and directorship.

In Great Britain there are over 200 separate companies comprising the chemical industry, and these range in size from medium to very large. Some buy all their power from the Area Boards, but many generate a large proportion of their own electricity; some of the private power stations exceed 100 MW in capacity, having large boilers around the 500000 lb/h mark at pressures exceeding 1700 lb/in^2. It is of interest that the first, and five out of the first seven, cyclone-fired boilers to be commissioned in this country are in chemical works.

The industry as a whole is far more highly instrumented than most others, and much of the original research and development work required to provide the most suitable instruments has been and is being done within the industry. Electrical engineers are employed in this field, and their work is not confined purely to electrical instruments or controls. Much of the original development of the fabrication, heat-treatment and welding of high-alloy steels was also done in the industry, and it is the main bulk source of metals new to engineering, such as titanium, zirconium, beryllium, germanium and silicon. Here again there are jobs for electrical men.

Much of the electrical equipment in the factories has to work in highly corrosive and/or explosive situations, and development work continues on complicated and delicate control apparatus required to function continuously in these conditions. Like the electricity supply industry, the chemical industry runs day and night all the year round, but instead of selling only one product—electricity—it sells literally thousands. The manufacture of these cannot be interlinked as electricity networks are, so that failure of electrical apparatus may have consequential effects that are financially out of all proportion to the cost of the failed equipment. This makes the planning of factory distribution systems, and the choice of the electrical apparatus, much more of an exercise in economics. The financial gain in standardizing materials and methods has to be balanced carefully against possible stagnation of thought.

In many of the chemical and processing industries the use of electronic control equipment, either by itself or associated with computers, is growing in importance where high speed and accuracy of control are essential and where the compounding of materials must be controlled at all times to give the most economical mixture. Such installations are used to determine the optimum parameters for a given reaction, and by automatically adjusting flows, pressures, temperatures and the like they give increased outputs of more consistent quality than can be obtained by manual control.

Many of the large firms in the chemical industry design their own chemical plant, buildings and services, including their power stations, as well as carry out the construction and operation of them. While, apart from instrumentation, it is true that little or no design of electrical machinery and apparatus is done, the lay-out of the factory distribution system, the sequence control of motors, and the development of special drives are highly specialized and require the application by well-trained engineers of the accumulated experience of many.

One of the outstanding advantages and a challenge to electrical engineers is that the chemical industry is staffed at professional level largely by university graduates,

including chemists, physicists, and engineers of various categories. These work in teams engaged on one of the many types of job, including research, development, design, erection, maintenance and operation. The bringing together of such people, highly trained in differing disciplines, is most stimulating.

There is much talk that engineers should specialize while young in a particular small section of engineering. This may be desirable and even necessary for the few, but the all-too-common custom in the engineering world of placing a young man in his late twenties on a job he is expected to do for life, such as switchgear design, protection engineering or overhead-line erection, etc., must be stultifying to anyone with a broad outlook and ambition. It is customary in larger firms in the chemical industry to move engineers about from one job to another at frequent intervals, at least for their first 10–15 years, in order to give them ever wider experience and so fit them for the highest posts. This applies to electrical engineers, especially those who are not too wedded to their own specialization.

The chemical industry, by the very nature of its business, must continuously look for new materials to make and sell, for cheaper methods of making better existing products, and for new markets. Competition in the world's markets is fiercer year by year. The chemical industry must be spending not less than £100 million every year on new assets. This is the challenge of the industry to young engineers, providing all the time new jobs, new problems and the opportunity of promotion.

The chemical industry has for many years spent much time, thought and money on training professional engineers. Postgraduate courses are run in many works, designed to comply with the requirements of the major Institutions, though some feel that the guidance given by these as to the content and especially the length of training is not the most suitable for the process industries. It is strongly held that intensive training and careful supervision should permit less time to be spent on the shop floor on tools and machines and so allow an earlier start on a responsible job where the young engineer's academic training could be used earlier and the keen man would always be made to feel a sense of urgency.

There are many openings for chartered electrical engineers in the chemical industry, and these are of a wide scope and at least as exciting and challenging as any that can be found in more traditional engineering fields.

Especially for those electrical engineers who are not content to jog along all their days in a narrow field, the close contacts in the chemical and allied processing industries with other engineers and with scientists, the continual striving after better plants and improved products, and the opportunity to spend large sums of money on one's own new ideas for improved chemical plants, many of which are at or near the frontier of technological knowledge, must prove a stimulating challenge.

SPECIAL GENERAL MEETING, 2nd NOVEMBER 1961

Members approve new Divisional plan

Corporate members voted on the 2nd November 1961 in support of the Council's plan for replacing the present specialized Sections by a Divisional structure, designed to improve The Institution's handling of its activities as a learned society.

Under the scheme, the present four specialized Sections will be replaced by three Divisions—Electronics, Power, and Science and General—and each Division will work through about ten relatively specialized Professional Groups. The 30 Groups will together cover the whole range of electrical engineering, and their number and coverage can be modified quickly to reflect any change of emphasis in the technological scene. New research and development can be followed up without delay by the formation of corresponding new Professional Groups.

At a Special General Meeting, proposals were made for certain Bye-law changes, which the introduction of the new structure will necessitate. On a show of hands, these were approved by an overwhelming majority of the 284 members present, only five voting against.

Interdependence

Little comment on the proposed Bye-law changes was offered. One member asked the meeting to consider carefully the possible effects of dividing The Institution's activities too firmly under 'electronics' and 'power'; to this Mr. A. H. Mumford (a Vice-President, and Chairman of the panel responsible for evolving the Divisional scheme) replied that the intention was to recognize the interdependence of these two branches of the science by a sufficiently flexible structure and a 'central' Division dealing with subjects of common interest.

Another member questioned the method proposed for registration of members in the Electronics and Power Divisions*; but, because this did not form part of the matter before the meeting—i.e. the amendment of the Bye-laws so as to permit the setting up of a Divisional structure—he was ruled out of order by the President.

Allowance by the Privy Council is needed before the necessary changes can be written into the Bye-laws, but the Council are losing no time in preparing for the introduction of the new scheme in October 1962; it is hoped that long before this the authority to proceed will have been received. A fuller report of the meeting, together with an account of Bye-law changes, will then be published in the *Journal*.

* It is intended that the method of registration of members in the Electronics and Power Divisions will be exactly similar to that applying for many years past to membership of the specialized Sections; for the Science and General Division nothing more than a request for registration will be required

SERIES CAPACITORS IN TRANSMISSION SYSTEMS

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Applications of series capacitors in transmission circuits are discussed. The beneficial effect of such installations on stability, power transfer, regulation and load sharing is considered. As a practical example, the economic background to the choice of a series-capacitor bank against alternatives is studied for a large American installation. Finally, the technological problems of series-capacitor protection are presented, and the practical solutions are outlined.

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R. O. M. POWELL, B.SC.(ENG.), GRADUATE

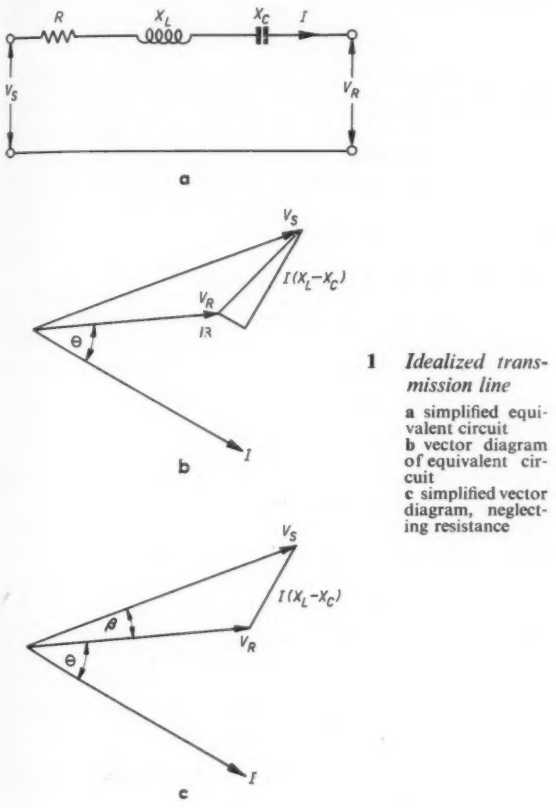
SERIES capacitors are of use in transmission and distribution circuits whenever it is desired to counteract the effects of the series inductance of the system. Excessive series inductance in a system usually results in one or more of the following unsatisfactory operating conditions:

(a) A large phase shift occurs between the ends of a system, so that instability develops at a power-transfer level that is too low, on the grounds of either economy or security

(b) The voltage drop becomes excessive

(c) Unequal load division of parallel feeders in a network occurs, restricting maximum power transmission.

Series-capacitor installations in transmission systems are usually undertaken when condition (a) occurs. Distribution-circuit applications are most usually concerned with problems of regulation, i.e. condition (b).



1 *Idealized transmission line*
a simplified equivalent circuit
b vector diagram of equivalent circuit
c simplified vector diagram, neglecting resistance

Improvements in the load division of parallel feeders can result from the use of series capacitors in transmission or distribution networks.

The characteristics required of capacitor dielectrics for all types of series application are usually the same, namely an economically rated capacitor for normal load conditions capable of being overstressed repeatedly for short periods without detriment to life. Installations on distribution systems usually require simple protective systems, to allow an economic rating of series capacitor to be used. When dealing with transmission applications, protective gear is complex: and the technological problems of development and design of suitable protective equipment have in the past, in spite of potentially large economic benefits, retarded the advancement of the series capacitor in this field.

Series capacitor as a transmission circuit-element

The use of the capacitor in shunt applications for industrial power-factor correction is well known, and the economic benefits of such installations can be readily demonstrated. While the benefits of series capacitors are equally tangible, they are not so easy to demonstrate. The rigorous calculation of the effect of series capacitors in long transmission lines is tedious rather than complicated. For this reason, the methods to be described are based on the technique usually applied to short transmission links, where the effects of line-charging current, or shunt capacitance, are neglected and the remaining line constants are depicted as 'lumped' instead of distributed values.

An idealized transmission link is shown in Fig. 1a, where R and X_L are respectively the total series resistance and inductive reactance in ohms, X_C is the ohmic reactance of a series capacitor, V_S and V_R are the sending- and receiving-end line voltages respectively, and I is the load current.

From the vector diagram Fig. 1b, the regulation or voltage drop ΔV of the system can be defined as follows:

$$\Delta V = \sqrt{3}\, I[R \cos\theta + (X_L - X_C) \sin\theta]$$

The reactance of the capacitor balances the inductance of the transmission link. This clearly has a beneficial effect on the system regulation. The conditions $X_L < X_C$, $X_L = X_C$ and $X_L > X_C$ are referred to as overcompensation, 100% (or full) compensation and undercompensation respectively.

In transmission systems, overcompensation is not used, although applications of this type are sometimes found in distribution systems and special load-circuit applications. Examination of the regulation formula shows that by varying the quantity X_C the regulation can be increased or decreased at will, provided that $\sin\theta \neq 0$. As θ is the phase angle, the condition $\sin\theta = 0$ represents unity load power factor.

Effect of circuit constants on series capacitors

It is common on long transmission links to transmit power at high power factors, i.e. $\sin\theta \to 0$, for general economic reasons. This does not invalidate the use of series capacitors however, as with long lines there is automatically a large phase shift or change in power factor along the length of the line, so that the capacitor can still improve regulation.

The relative magnitude of the line resistance R and reactance X are also important when considering the effects of capacitors on regulation. Low values of resistance compared with reactance provide the best condition for series-capacitor applications. This is usually the case for transmission lines operating at high voltages with large-diameter line conductors. Series-capacitor installations for regulation in distribution circuits with small conductors are often not practicable, however, because of adverse R/X ratios, unless overcompensation is contemplated.

Rating and output of a series capacitor

As the capacitor is in series with the transmission line, it must be capable of carrying the load current of the line. The reactive-power rating, or output, of the capacitor is $I^2 X_C \times 10^{-3}$ kVAr per line, and the output varies with the line current. For the shunt capacitor, the output of a capacitor bank is controlled by the applied voltage, and a fixed level of correction is therefore provided, irrespective of load current. One attractive feature of the series capacitor is this dependence of output on load current, for it is entirely automatic and immediate in response; while, in the shunt case, switching routines of subdivided banks, initiated by relays, have to be used to provide a system responsive to the demands of the load.

The series capacitor and power transfer

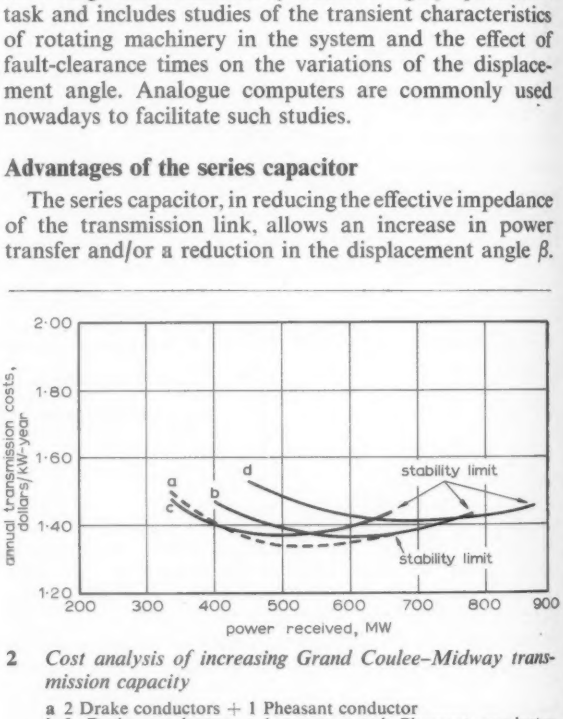
The vector diagram Fig. 1c can be used to derive a well known formula for power transfer. If P is the power per phase, then $P = V_R I \cos\theta = V_S V_R \sin\beta/(X_L - X_C)$. The power transfer can be seen to vary inversely with the equivalent inductance and directly with the sine of the angle β between the receiving- and sending-end voltages. Theoretically, maximum power transfer for a fixed equivalent inductance occurs when $\sin\beta = 1$ or $\beta = \pi/2$.

For transmission systems, however, values of β must be restricted to an angular displacement of 15°–20° for the phase shift between sending and receiving terminals of the link. This is because angular displacements also occur in the generating equipment, distribution circuits and load, which together must total less than $\pi/2$. The total angular displacement from end to end of the complete system must be controlled to a value less than $\pi/2$ to allow some margin for any transient disturbances caused by faults in the system.

The evaluation of safe-working angular displacements for a large interconnected system is a highly specialized task and includes studies of the transient characteristics of rotating machinery in the system and the effect of fault-clearance times on the variations of the displacement angle. Analogue computers are commonly used nowadays to facilitate such studies.

Advantages of the series capacitor

The series capacitor, in reducing the effective impedance of the transmission link, allows an increase in power transfer and/or a reduction in the displacement angle β.



2 *Cost analysis of increasing Grand Coulee–Midway transmission capacity*

a 2 Drake conductors + 1 Pheasant conductor
b 2 Drake conductors + 1 compensated Pheasant conductor (series capacitor of 28·6Ω reactance)
c 3 Drake conductors
d 4 Drake conductors

The most important practical advantages that result from such a use, with respect to power transfer, are:

(i) An increase in power transfer for a fixed displacement angle, i.e. the power-stability limit of the system is increased

(ii) A more economic choice of numbers of parallel circuits and/or system voltage may be possible, provided that the capacitor is considered as part of the transmission equipment in the planning stage.

Distribution of load in parallel circuits

In a power system, transmission links between the power production and utilization centres always consist of multiple 3-phase circuits. With an interconnected system, these parallel circuits may not traverse the same route or they may consist of circuits using differing conductor sizes, mechanical constructions, terminal transformers, etc. The effect of such dissimilarities is often a situation where economic load sharing between the parallel circuits is difficult to arrange and, in addition, the limit of power transfer through an interconnected network still occurs when the transfer in only one of the circuits reaches a maximum level.

Considering a simple case where the transmission circuits have identical length and constructional features but different conductor cross-sections, the load will divide in the ratio of the circuit impedances, i.e. if P_1, Z_1 and P_2, Z_2 are the power loading and impedance of the two circuits, then $P_1/P_2 = Z_2/Z_1$. The ideal division from the economic point of view would be $P_1/P_2 = R_2/R_1$, where R_1 and R_2 are the resistances of the two transmission lines.

As was pointed out earlier, the reactance of a line conductor does not decrease linearly with increasing conductor size, as does the resistance, so a series capacitor can be used to modify the line reactance to provide the desired impedance characteristic. If $R_1 < R_2$, and X_1 and X_2 are the reactances of the transmission lines, a series capacitor of reactance $X\Omega$ can be chosen so that the ratios $R_1/(X_1 - X_C)$ and R_2/X_2 can be made identical, in which case $P_1/P_2 = Z_2/Z_1 = R_2/R_1$. Before the advent of series capacitors, the impedance of parallel circuits could be adjusted only by increasing the impedance of the circuit having the least reactance by inserting a series reactor.

If $R_1 < R_2$ as before and X_R is the reactance of a series reactor, the ratios can be adjusted so that $R_1/X_1 = R_2/(X_2 + X_R)$. This arrangement is obviously inferior to the capacitor method, as the impedance of the parallel circuits is increased, impairing the regulation and the power-transfer characteristics. On the other hand, the use of a capacitor improves the regulation and stability characteristics of the system.

A practical example

The following example of the application of series capacitors is taken from a study made of a 100 mile 230 kV transmission link in the Bonneville Power Administration system in the United States.*

The problem was to extend the transmission capacity provided by an existing twin-circuit transmission line between a hydroelectric station at Grand Coulee and an intermediate point on the system, known as Midway. Future plans included reinforcement that would provide alternative means of feeding load centres beyond Midway. The timing of these extensions was uncertain, however, and it was necessary to carry out reinforcement of the Grand Coulee–Midway link, bearing in mind that on completion of the extensions the load would fall substantially.

The method adopted for the proposed extension had, ideally, to provide the increased capacity at minimum cost and to permit operation at a high level of loading initially, and finally at a reduced level, with the minimum of operational cost in both cases. The existing transmission line consisted of two 230 kV circuits using steel-cored aluminium conductors of 0·393 in.^{2} equivalent copper area—'Drake conductors'.

Four alternatives were considered:

(a) The construction of a third circuit with 0·628 in.^{2} equivalent-copper-area conductors—'Pheasant conductors'
(b) The construction of a third circuit with Pheasant conductors including a series capacitor in the third circuit rated at 59400 kVAr
(c) The construction of a third circuit with Drake conductors
(d) The construction of a third and a fourth circuit with Drake conductors.

The modified Grand Coulee–Midway system was required to transmit up to 750 MW before alternative reinforcement could be introduced; subsequently, the load was anticipated to fall to 300–400 MW.

Comparison of alternative systems

The annual transmission costs of the four alternatives were evaluated. The costs included charges for operation and maintenance and for the interest and replacement of the capital cost of the new equipment for each reinforcement scheme. Fig. 2 shows the results of this examination in the form of a graph of annual transmission costs in dollars per kilowatt-year against transmitted power in megawatts. The stability limit shown on each characteristic corresponds to a line displacement angle of 20°. This value had previously been determined by computer studies of the system.

Curve **a** shows that the addition of a Pheasant-conductor circuit to the existing Drake circuits provides the most economic operating condition for 380–600 MW loads. The arrangement is not capable of transmitting 750 MW, however, and so could not be considered for the initial part of the reinforcement programme.

The use of an additional Pheasant-conductor circuit with a series capacitor (curve **b**) increases the stability limit to 780 MW, and the most economic loading condition for this arrangement is in the 600 MW region. By the use of a series capacitor, the transmitted capacity has been increased by 120 MW over scheme **a**. The incremental cost of this increased capacity, scheme **a** against scheme **b**, was $765000. This increase in capital cost is reflected in the higher annual costs at lower loading for scheme **b**, while at higher loadings the improved operating efficiency of the compensated arrangement more than offsets the contribution of the increased capital charges.

* DEMUTH, O. A., and HARRINGTON, E. J.: '230 kV series-capacitor installations on Bonneville Power Administration's system', C.I.G.R.E., Paris, 1954, paper 327

The effect of building an additional circuit with Drake conductors (identical to the existing circuits) is shown in curve **d**. This again is not a practical proposition because of the low-stability limit, and, even if this could be improved, the operating costs at loads above 400 MW are higher than in alternative **a**. Curve **c** shows the effect of building two additional Drake circuits. Here the stability limit is more than adequate for the short-term requirement. The capital cost of this scheme was some $2 410 000 above that of scheme **a**, however. This is reflected in the high annual cost throughout the range of power-transfer values under consideration.

The final solution

Alternative **b** was chosen as the best method for meeting the short- and long-term requirements. After the period of loading up to 750 MW had passed, the capacitor bank could be removed and re-employed elsewhere in further series or shunt application. The characteristics of scheme **a** would then apply to the system for power transfers of 300–400 MW.

The series-capacitor bank was to be built on the system of using small unit-type capacitors connected in series–parallel groupings. This would facilitate further use of the capacitors at other sites when they were removed from the Grand Coulee–Midway line. The useful properties of the series capacitor in increasing stability limits and assisting in problems of load sharing are clearly demonstrated in this example. In addition, the use of a series capacitor in the transmission system offered attractive annual costs, from both the capital and the operating expenditure points of view. The extreme flexibility of capacitor banks built on the unit principle is also an attractive feature in times of rapid expansion of the system.

Protection of series capacitors

As was shown earlier, the output of a series capacitor is a function of line current $I^2X_C \times 10^{-3}$ kVAr per line. On transmission systems, during fault conditions, increases in line current of an order of magnitude are not uncommon. Such a condition would result in the capacitor bank providing a hundredfold increase in output over the full-load condition.

In spite of the fact that faults persist for short intervals, it is never an economic proposition to design capacitor dielectrics to withstand such overloads without protective devices. The economic solution for large banks is always to design for the full-load line-current conditions and to provide protection against damage to the capacitors owing to overvoltages during overload conditions.

Requirements of the protective scheme

The overvoltage condition on the series capacitor arises when currents in excess of normal-load current flow through the capacitor impedance. Most capacitor-protective schemes make use of the increase in voltage across the terminals of a series-capacitor installation in a fault condition to initiate the protective circuits. In the simplest form, the protection consists of a spark-gap set to arc over at a predetermined level. Operation of the gap at the desired level effectively short-circuits the capacitor and removes the overvoltage.

When faults occur in long transmission systems, stability is endangered owing to the transient variations in displacement angle, caused by the onset of the fault current and by the loss of transmission capacity of faulty circuits during clearance. It is at times such as these that the beneficial effects of a series capacitor on stability margins are most required. During these conditions the capacitor-protective system must reinsert the capacitor as soon as possible after fault clearance.

Simple spark-gaps will not, unfortunately, perform this function of rapid reinsertion, as, once the arc is initiated in the fault-current condition, the reduction to the load-current level, on fault clearance, passes unnoticed by the gap, which carries on conducting. For this reason, a form of self-extinguishing spark-gap is usually employed. In addition, a typical system would include a by-pass switch and a back-up gap, both placed in parallel with each phase of a complete series-capacitor installation. A schematic of a protective system with means for isolating the series-capacitor bank is given in Fig. 3.

Functions of the protective equipment

The functions of the various items of equipment are:

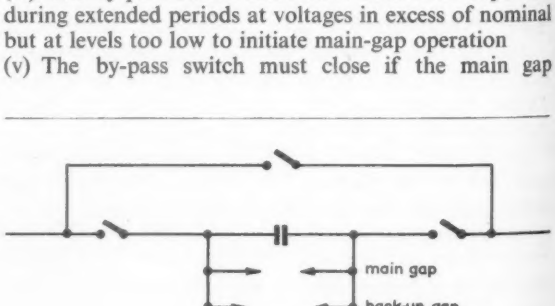
(i) The main gap must flash over at predetermined levels to protect the capacitor dielectric from overvoltages during the passage of fault currents. The gap calibration must not vary with repeated operation

(ii) The back-up gap is provided so that, in the event of non-operation of the main gap, some means of protecting the capacitor bank from rapid increases in applied voltage is available

(iii) The capacitor must be reinserted in the line automatically, and, where considerations of stability are concerned, the reinsertion must be as rapid as possible. In normal fault conditions, the main gap ensures that these requirements are met by virtue of the self-extinguishing feature

(iv) The by-pass switch must close across the capacitor during extended periods at voltages in excess of nominal but at levels too low to initiate main-gap operation

(v) The by-pass switch must close if the main gap



3 *Series-capacitor-protective system*

continues arcing for an excessive length of time or if the back-up gap flashes over

(vi) The by-pass switch can also be arranged to close to cater for faults internal to the capacitor bank that do not constitute system faults, i.e. serious changes in capacitance of the capacitor-bank subsections owing to failure of unit capacitors etc.

Some practical considerations

Self-extinguishing gaps have proved difficult to design, but satisfactory systems have now been developed working on both the air-blast and the magnetic blow-out principles. The setting for the main-gap initiation is usually about 2½ times the rated voltage of the capacitor bank. Work on capacitor dielectrics has demonstrated that the capacitor units can stand such transitory overvoltages without any serious detriment to life.

Design of the over-all equipment is complicated by the fact that large installations of capacitors weighing many tons have to be installed with full line-to-earth electrical clearances. Auxiliary supplies for the operation of the protective gear must also be isolated from earth. The technological difficulties in the development and design of protective systems to meet the onerous conditions outlined have been responsible for the slow introduction of series-capacitor systems mentioned earlier.

These difficulties have, however, been overcome, and there are now a number of large series-capacitor installations, with automatic protection of the type described, working satisfactorily.

Summary

The value and practicability of large series capacitors as an integral part of transmission-system installations have already been demonstrated in Sweden and the United States. Capacitor installations are particularly effective on transmission lines where problems of load transfer, stability and load sharing are under consideration. Large economic benefits, both in initial capital cost and in operational expenditure, can be achieved by the intelligent use of the series capacitor. Moreover, the use of series capacitors has extended the maximum distance that power can be transmitted with alternating current.

Now that operational experience of large installations is available, the number of series-capacitor applications in a.c. transmission systems can be expected to grow in sympathy with the inevitable increase in the world-wide demand for electrical energy.

BRITAIN'S DEMAND FOR SCIENTIFIC MANPOWER IN THE NEXT DECADE

THE Statistics Committee of the Committee on Scientific Manpower of the Advisory Council on Scientific Policy have prepared a Memorandum (Cmnd. 1490) 'The long-term demand for scientific manpower' (H.M.S.O., London, price 1s. 9d.). The report presents a well balanced and clearly argued forecast of the possible future demand for, and supply of, scientists and technologists. It reaches the heartening conclusion that we may expect to reach a balance between supply and demand, which up to now has seemed almost as remote as the end of the rainbow.

Supply and demand

Much of the comment made in the Press carried headlines strongly implying that there would be a surplus of scientists and technologists in the relatively near future. The report itself, however, goes no further than suggesting that this might be so towards the end of this decade, if a number of assumptions are in fact justified. It is unfortunate that this single comment in the report has received so much publicity, because, if it is misinterpreted by the general public and the academic world, and so deters young men from entering careers in science and technology, then all the forecasts of supply may fall to the ground.

The present trends in availability of places and numbers of students give reasonable assurance that the estimated output will be achieved. The forecasts of demand must inevitably contain much more uncertainty, and the report indicates that earlier forecasts, based on a linear relation between productivity and the number of scientists and technologists employed, were wrong.

The present forecasts are based on the assumption that industry will absorb scientists and technologists up to an arbitrary saturation point. This might be justifiable in research and development activities, where once a team is established it addresses itself to a programme of work that constantly changes but does not increase. It is very doubtful, however, whether this will be the case in the electrical industry. The advent of radar, atomic power, computers, automatic control, etc. opened up an increasing demand for engineers and scientists to exploit the application of each group of devices, and experience suggests that the limits on progress are set by the availability of suitably educated and trained men.

Assumption not justified

Although the report defines and explains the many assumptions on which the forecasts are based, an important one appears to have been somewhat, but not entirely, overlooked. It tacitly assumes that every young man who successfully completes an academic course is going to be an effective scientist or technologist. Industrial experience shows that this assumption is not justified. Undoubtedly, there is some truth in the statement that there is misemployment of academically qualified people in industry, but some people with good academic qualifications are not really capable of doing effective work at the level that these qualifications would suggest. The converse is also true.

Comparison with the United States

In comparing our technical strength with that of the United States, the report wisely combines the technician and technologist figures and, setting these against the American ones, shows that, on this basis, Britain has a slight edge on the United States at the present time.

RESEARCH REACTORS DISCUSSED IN VIENNA

Symposium on the programming and utilization of research reactors, 16th–21st October 1961

A SYMPOSIUM on the programming and utilization of research reactors (not greater than 5 MW output), convened by the International Atomic Energy Agency (I.A.E.A.), was held in Vienna from the 16th to 21st October 1961. It was attended by 198 delegates from 35 countries. The main object of the symposium was to allow the many countries that are acquiring research reactors to benefit from the experience gained by the older-established research-reactor centres. In addition, it was hoped that the more advanced laboratories, apart from exchanging information one with another, might find means by which they could fruitfully collaborate with and assist the newer establishments.

The subject-matter of the individual sessions divided roughly into four parts: the planning and organization of nuclear-reactor centres; accounts of the experience gained in the utilization of reactors; reports on specific research programmes; and a discussion of the possibility of co-operation between the newer and older research centres.

Planning and organization of nuclear-reactor centres

The papers on planning and organization of nuclear-reactor research centres stated and restated rather monotonously what appeared to be just common sense, i.e. that the national objectives behind the establishment of a reactor centre should be clearly evaluated, that the research programme utilizing the reactor should be carefully formulated and the reactor chosen should be that which was best suited to meet the requirements of the programme, that the training of the research staff and supporting technicians should be phased so that they were available fully-trained for the commissioning of the reactor, etc., etc.

It was therefore disturbing to learn that, in fact, what appeared obvious in retrospect was not always so obvious. National prestige was not sufficient justification for the establishment of a costly reactor centre; the expenditure on such centres should be commensurate with the total national product. A disproportionate effort in the nuclear field would starve other research activity and give rise to the evolution of artificial 'nuclear' solutions to technological problems. Notwithstanding this, it was pointed out that the development of a nuclear solution to a problem could have beneficial side-effects if it promoted as a consequence a superior 'non-nuclear' solution. It was suggested that the element of competition introduced by the nuclear-power programme in the United Kingdom might have had a beneficial effect on the economic efficiency of conventional means of power production.

Reactor design

In the discussion on the papers, views were expressed on the most appropriate design for a research reactor. Naturally, no positive conclusion was reached, since the reactor design could not be divorced from the purpose to which the reactor was to be used. Thus, though cogent reasons were given for choosing a 5 MW swimming-pool reactor as a multi-purpose reactor for a national centre, it was equally clear that a case could be made out for the very much less expensive 10–100 kW Argonaut-type reactors to satisfy specific research programmes, as for example in neutron physics.

Utilization and research programmes

Progress reports were given on the research programmes of the majority of 166 research reactors now in operation. The field of application of reactors was vast, having ramification in these subjects: reactor engineering, nuclear and solid-state physics, neutron diffraction and spectroscopy, radiation chemistry and radiochemistry, isotope production, irradiation damage and metallurgy, radiobiology, medicine and agriculture. The following topics provoked much discussion.

For the study of the effects of radiation on materials, a reactor is pre-eminent as a source of intense radiation. In-pile irradiation, however, involves bombarding the specimen with a mixture of γ-rays as well as fast and thermal neutrons. To elucidate the contribution of each of these components to the damage produced requires pure fluxes of a single component. The conventional means of obtaining γ-ray fluxes is to use either spent fuel-elements or artificial radioactive sources, such as cobalt or caesium, that have been manufactured in a reactor.

Recently, γ-ray facilities have been constructed in which indium, either in the form of a sulphate or alloyed with gallium, is circulated through the reactor, where it becomes radioactive, to an irradiation cell outside the reactor. By this means, γ-ray fluxes in excess of 1000 r/min have been produced with the advantages that, owing to the short half-life of the indium, speedy access to the cell is possible after irradiation and that, by using suitable configurations of the circulation system, the dose rate may be shaped to a wide variety of specimens that require irradiation. A novel application of this facility has been in the maturing of cognac: it was regretted that no samples were available for the delegates.

Medical and electrical-engineering fields

An application of reactors in the medical field, which aroused great interest, was the therapeutic treatment of brain tumours. The technique adopted (at the Massachusetts Institute of Technology) relied on the selective absorption of sodium borate by the tumour tissue. Treatment consisted of thermal-neutron irradiation of the exposed brain for 1 hour at a neutron flux of 5×10^8 n/cm^2-sec. The number of terminal patients treated so far was insufficient to permit positive claims as to the value of neutron-capture therapy.

Useful research in the electrical-engineering field is being pursued. Neutron diffraction continues to unravel the mysteries of magnetic materials: in addition to ferro-, ferri- and antiferromagnetic materials, the catalogue of magnetic structures now subdivides to include helical, sinusoidal, triangular and other subspecies of the three main classes. Research on the effects of radiation on solid-state devices continues, the main conclusion being that *n*-type semiconductors are converted into *p*-type.

International co-operation

The symposium concluded with a discussion on ways and means of international co-operation between research-reactor centres. Despite the growth of supranational organizations, such as Euratom, and the signing of many bilateral agreements, it was felt that the I.A.E.A. still had important functions to perform. For example, it was suggested that

the I.A.E.A. should publish a compilation of research programmes being pursued with reactors. It was also desirable that it should act as a sort of employment agency, providing the less-technologically-developed nations with consultants.

The value of the I.A.E.A. as a convener of conferences was demonstrated by the large attendance at this symposium. Over 100 papers were presented; these will appear in the proceedings of the symposium to be published early in 1962 by Academic Press Inc. (London). W. K. MANSFIELD

DEVELOPMENTS IN POWER REACTORS

Symposium on power-reactor experiments, Vienna, 23rd–27th October 1961

THE symposium on power-reactor experiments, held in Vienna from the 23rd to 27th October 1961 and organized by the International Atomic Energy Agency, was attended by nearly 200 delegates from 24 countries. Four main types of reactor experiment were discussed:

1. High-temperature gas-cooled reactors
2. Aqueous homogeneous-suspension and molten-salt homogeneous reactors
3. Fast breeder reactors
4. Nuclear superheat reactors and steam-cooled reactors.

There was also a session on a variety of specific experiments outside these categories.

Dragon project and pebble-bed reactors

The Dragon reactor project has a number of interesting design problems that require considerable research and development effort. The engineering problems have been reduced, as far as possible, to known proportions, so that the amount of development and proving of new components is minimized. Reliability and simplicity are important. Position-measuring transmitters are of two types. For fine-position indication, synchro transmitters are used with a limited angle of rotation: ligament connections take current to the rotors. Coarse-position indicators are of the rotary pick-off transmission type. A simple iron rotor changes the flux linkage between dual stator-windings with fixed electrical connections.

The experimental beryllium oxide reactor (EBOR) under construction in the United States is designed mainly for fuel-element testing. Supporting experiments include a detailed programme of control-rod-drive tests in high-temperature helium at elevated pressures.

Problems on the pebble-bed reactor were described with particular reference to a 10 MW thermal reactor that would give operational experience for large power reactors. The main difficulties of such a system are expected to be the maintenance operations on a contaminated high-pressure-gas system. This leads to the problem of simple reliable control circuits and equipment. Remote-handling equipment and closed-circuit television will play an important part in the successful operation of the plant.

In a theoretical study, a rhombohedrally packed pebble-bed reactor was suggested as an improved system. Although this technique would achieve the best power distribution in the core, there are inherent engineering difficulties in obtaining regular packing of the pebbles.

Homogeneous-suspension and molten-salt reactors

Problems associated with an aqueous homogeneous-suspension reactor were outlined. One method of determining the colloid-chemical stability at temperatures above 100° C has been developed. This is a gold-lined steel autoclave in which the solid concentration at any distance below the liquid level can be measured by the absorption of soft γ-radiation or X-rays. Control of the temperature of the suspension to $\pm 0{\cdot}05$° C is obtained by a resistance thermometer in a Wheatstone bridge heating, via a thyratron amplifier and matching transformer, a length of the stainless-steel piping of the main circuit.

In the molten-salt reactor a molten-salt fuel is circulated through graphite channels. The reactor temperature can be varied by adjusting the amount of uranium in the salt. The corrosion problems are not yet fully appreciated, and intricate remote-maintenance methods will be employed, for which a system of stereotelevision has been developed.

Fast breeder reactors

Various fast-breeder-reactor concepts were examined. In the French 'Rapsodie' reactor programme, many experiments have been conducted. Both mechanical and electromagnetic sodium pumps have been investigated. A novel safety device is a fusible rotating linkage. The BR5 fast reactor, operating in the Soviet Union at 5 MW thermal output, uses plutonium oxide fuel and sodium coolant. The reflector is natural uranium surrounded by a thick layer of nickel. The neutron flux at the core centre is $8{\cdot}2 \times 10^{14}$ n/cm^2/sec. Temperature and power coefficients and kinetic behaviour were described.

The fast breeder reactor at Dounreay was described, and a similarity to the BR5 was observed. The entrainment of nitrogen blanket gas into the sodium and the problems associated with a high level of impurities in the coolant were discussed. Gas has also been experienced in the BR5 circuit, but impurities have been avoided by extensive cleaning and filtering operations. The great complexity of the project was emphasized, although any future projects of a similar type would undoubtedly be simplified to facilitate both operation and maintenance.

New problems

Nuclear superheat and steam-cooled reactors have raised several new problems. Thermocouples have been produced to measure the central temperature in the fuel rod.

A 65 MW experimental reactor for ship propulsion was described. This incorporates a well designed telescopic-action shut-off-rod system, and will achieve great economy in capital cost.

The main problems arising from the various reactor systems are almost equally divided between reactor physics and reactor engineering. There is an increasing emphasis on completely reliable remote control and on the question of remote maintenance where high levels of radiation may occur in working areas or where equipment is completely inaccessible except during a major shut-down of the plant.

R. GAUSDEN

PURE AND APPLIED SCIENCE

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The education of physicists gives them an advantage, in original creative electrical engineering, over traditionally educated electrical engineers. Further, the prestige and publicity given to 'science', largely owing to its successful applications, discourage many of the best students from taking electrical engineering. The author considers these facts and suggests remedial action by the universities and The Institution.

This article is based on part of the author's Chairman's Address to the Scottish Centre. The Address was given before the South-East Scotland Sub-Centre at Edinburgh on the 3rd October, before the South-West Scotland Sub-Centre at Glasgow on the 4th October, and before the North Scotland Sub-Centre at Dundee on the 12th October and at Aberdeen on the 13th October 1961.

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Prof. E. G. CULLWICK, O.B.E., M.A., D.SC., F.R.S.E., MEMBER

THE past 20 years have seen an astonishing development in the applications of electrical science. The Second World War was, of course, the great stimulus, and the significant point about the wartime developments is that many of them were the work of physicists and not of electrical engineers. Perhaps there were, in fact, engineers who might have done these things if they had not been too busy, but I suspect that the matter goes far deeper than this and that the physicists were better equipped by their quality, education and experience to create new applications and to find practical solutions to urgent problems.

It is now a commonplace that many honours graduates in physics pursue careers in electrical engineering and that the physics departments in universities attract a far greater proportion of really able students than do the departments of electrical engineering. Further, the British universities, including the great colleges of science and technology, are today producing more than twice as many graduates in pure science, as it is called by the University Grants Committee (U.G.C.), as in technology.

Achievements of science—or engineering?

In Britain as a whole, the demand for university places in engineering departments seems to have slackened in the last few years, in comparison with science, in spite of the spectacular achievements of engineering since the war. The popular misconception of the nature of these achievements may be a major contributory cause, for they are commonly known as achievements of science, it being generally overlooked that, while they are the fruits of science, they are the achievements of engineering and technology.

Let me take an example: each week John Davy writes an article in the *Observer* as 'Science Correspondent'. When he can find a suitable subject, he does indeed write about pure science, but quite often he writes about applied science. A typical article appeared in the issue of the 27th August 1961 entitled 'Plugging in to the sun'. It is about the United Nations conference at Rome on new sources of energy and the great need of the underdeveloped countries for cheap power. Let me quote two typical statements: 'two French scientists described to the conference a solar-powered ice-maker' and 'perhaps the greatest success of the conference has been a small solar-power plant which Israeli scientists have installed on a farm just outside Rome'. Is it surprising, then, that a bright boy, with creative engineering ability, eschews an engineering degree as something inferior and goes in for science?

He goes in for science and frequently ends up, in fact if not in name, as an engineer. Only a comparatively few science graduates pursue careers in pure science, the great majority working on problems concerned with its applications, and distinguished scientists are accepting as right and proper the engineering function of the physicist.

At a meeting of the British Association for the Advancement of Science a few years ago, Sir George Thomson expressed the view that the engineer was fundamentally a designer. The engineer, he said, depended on the relevant theory so far as it had been discovered and on the experience of himself and others with similar designs of the past. On the other hand the physicist, Sir George continued, had little of the engineer's 'know-how'; he was best at those industrial problems where development was very rapid, where little know-how had accumulated, and in which his superior ability to look at things from first principles had full play; his business was to get the thing to work somehow, and the engineer's job was then to tidy it up and make something that could be worked by a housewife.

Intellectual work of the engineer

It is strange that this eminent physicist is apparently unaware of the contributions that electrical engineers have actually made to 'relevant theory'. Between the fundamental mathematical laws of electromagnetism, for example, and their successful application there is a big theoretical gap that has been bridged almost entirely by electrical engineers. A classical example of this is the theory of the magnetic circuit as applied to actual electromagnets. No one knew how to apply

Maxwell's equations to such problems until John Hopkinson and Gisbert Kapp sorted out the theory into a workable form, and a vital contribution was made by F. W. Carter in applying mathematical methods to determine the field distribution in such difficult cases as a slotted armature.

Heaviside's operational calculus, the work of Steinmetz and others in developing the j-method of dealing with alternating currents, the concept of the equivalent circuit of a thermionic valve, and the brilliant achievement of Kron in laying the foundations of generalized machine theory, all these are examples of the engineer's work on the highest plane of imaginative intellectual effort. It is no exaggeration to say, in fact, that it is the electrical engineer who has often taught the physicist how to use his own laws.

These widespread misconceptions, without a doubt, present a challenge both to The Institution and to the university departments of electrical engineering. Industry will naturally look for the best man, irrespective of his label, and at present it seems indisputable that in the most progressive sections of electrical engineering the best men are frequently to be found among graduates in physics. I believe, therefore, that university departments of electrical engineering must take a much more active interest in electrical science as a whole, and this inevitably means a critical look at our courses.

Re-examination of electrical-engineering courses

The usual type of first course in electrical engineering, in most of the British universities, follows a roughly uniform pattern. Starting with a rather brief treatment of electrostatics and electromagnetic theory, the student is soon introduced to d.c. and a.c. circuit theory and even to a detailed study of the theory of some machines. It has become part of the established pattern to cover this engineering content in order to prepare for the more advanced technical courses of the third year, and little time is available for a more thorough study of electrical physics.

This may be satisfactory for the student who does not proceed beyond the ordinary degree, but I do not think it can be so considered for the more able student who is fitted to take honours. Starting strictly technical studies at this early stage, the inevitable result is that the honours graduate has studied electrical-engineering theory to a high standard but on a very weak scientific foundation. He is far too much a specialist in what has already been accomplished in electrical engineering and too little prepared to contribute to developments of the future.

If we are to strengthen the scientific basis of the honours course, therefore, the obvious place to start is by a thorough revision of the conventional first course. It could well be devoted to a continued study of classical physics, particularly electrical physics, but with some emphasis on those developments of fundamental theory of particular interest to the engineer. Basic applications can be studied at appropriate points, with the view of illustrating the practical working of the fundamental laws.

Importance of physics

The important point here is that the applications should be shown as arising naturally from the physics, rather than a particular application being taken as a starting-point. As an example, the theory of the ferromagnetic circuit, of so much importance in machine design, should be developed from the general laws of the magnetic field. This is the place, too, to show how the theory of electric circuits, with the laws of Ohm and Kirchhoff, and the laws of electromagnetic induction have their roots in the concept of the electric field. The general laws of the electromagnetic field can be studied at least in their integral form, with electromotive and mechanical forces governed by the laws of energy conversion.

Much can also be done in electronic and atomic physics, the conduction of electricity through gases, electron dynamics, atomic structure, and the electrical and magnetic properties of materials. Appropriate work in the laboratory must form an important and integral part of such a course, and there is much scope here for devising new experiments to illustrate the fundamental physics, with a decreased emphasis on the over-all behaviour of complete items of equipment.

If a student can, at this stage, gain a real insight into the essential unity of electrical physics, he will be in a position to branch out into a particular specialized field with increased confidence and effectiveness. That this is so has been shown by our ten years' experience, in the University of St. Andrews, with students of electronic physics who have taken the third- and fourth-year courses in electrical engineering after having spent their first two years in the Faculty of Science. On the whole they have done remarkably well, and the value of their more comprehensive scientific background has been quite evident.

To complete the process, however, this increased emphasis on fundamental physics, including what is commonly known as modern physics, must be carried on into the senior years, this being particularly important for those who choose to take electronics at the honours standard. A student so grounded should be able to apply his knowledge of electrical science in any direction and to see the essential unity behind all branches of electrical engineering. Although at the more routine level there may well be a marked division between power engineering and electronics, at the higher levels of creative work, both in theory and in practice, any such division may prove an impediment. In particular, in control engineering the two are intimately merged together. It is therefore essential that there should be no artificial academic barrier where no natural barrier exists.

Confusion of roles

It would not be reasonable, of course, to maintain that the electrical engineer should be capable of doing

all the work necessary in creative electrical engineering. This would be absurd, for progress obviously depends on the combined efforts of specialists covering the whole range of physical science: physicists, mathematicians, chemists and metallurgists all have their important parts to play. The essential functions of the electrical engineer and the physicist, however, should not be confused. The engineer's true role is that of creator, whereas the role of the physicist is properly that of investigator. The present tendency to confuse these roles is dangerous, for its inevitable result is a weakness in engineering and a diversion of science from its true purpose.

The place of science

If one studies the long struggle in the last century to give science its place in British universities, one thing becomes clear. It was not science for its own sake that was stressed, but its utility. The Paris Exhibition of 1867 showed beyond any doubt that Britain was being overtaken, industrially, by continental countries and particularly by those, like Germany, that had actively developed scientific and technical education. So in the great period of university expansion that followed, when many of the 'red-brick' universities and university colleges were founded, science took an important place but with a distinct utilitarian bias.

It was realized, however, that before the fruits of science there must be the seed, and that the source of the seed lies in pure and disinterested scientific investigation, requiring an attitude of mind not previously evident in the universities. It may now seem unbelievable that the great Cambridge mathematician, Todhunter, opposed the teaching of experimental physics in schools as weakening the master's authority: the boys should accept the master's word. It is science, more than anything else, that has blown the heavy and stultifying weight of authority and dogmatism out of our academic windows and brought in its place the vital air of intellectual freedom.

Nevertheless, if it was potential utility that brought science into the universities, this is even more the ultimate motive for the present great academic expansion of the physical sciences. Today's university expansion is almost entirely financed by the Government through the agency of the U.G.C., and the size of the cheque is a measure of the national urgency. It is concern for the industrial and economic health of the nation, not a concern for pure science as such, that is behind the Government's policy.

Just before the war, science students outnumbered those of technology in our universities by 30%, and in 1959 this preponderance had risen to 50%, owing to their potential value in industry. The U.G.C., somewhat strangely, includes these science students under the title 'pure science' although 'microwave engineering' forms an accepted field of work in at least one physics department. It is evident, from all this, that the preservation of the pristine spirit of science is no easy matter.

Difficulties of pure-scientific research

Fundamental research in physics has now left far behind the days of string and sealing-wax, and much of it has to be done on electromagnetic machines—marvels of electrical engineering—costing millions of pounds and housed in Government establishments. The difficulties of pure-scientific research were never better illustrated than by the Jodrell Bank radio telescope. In its early days, this project ran into financial difficulties that were reported in the daily Press, but that was before the Soviet Union circled the globe with its sputniks. A device designed to detect extremely weak electromagnetic waves coming from outer space suddenly became a national asset, which is now, we hear, to be used as an early-warning radar for possible hostile rockets. We hear no more about financial difficulties.

Scientists, of course, do their best to stress the importance of pure science, but one fears that they may be fighting a losing battle. Perhaps too, in their anxiety, they may be led to overstate their case and to claim too much. For instance, 40 years ago it was sufficient for Sir Richard Gregory, in his book 'Discovery, the Spirit and Service of Science', to 'seek to justify the claim of science to be an ennobling influence as well as a creator of riches, and therefore as much importance is attached to motive and method as to discovery and industrial development, however marvellous or valuable these may be'. Notice that he claimed *equality* of status, no more, for pure and applied science, but this is not the view widely held today.

Let me quote Sir George Thomson's ideas once again. 'I believe', he said, 'that science as a system of knowledge is more important than the applications to which it leads, and that it has a value, and that the effects of science on men's minds are more important than its effects on their material life.' Similar views have recently been expressed by Prof. Herbert Butterfield, a historian and recently Vice-Chancellor of Cambridge University, who considers that we ought to value science more than technology.

Mutual dependence of science and technology

In the face of the utilitarian pressures of today, one might well sympathize with the philosophy behind these statements, were it not for the fact that they attempt to separate the inseparable. The whole experience of man is that scientific truth is never sterile and that science and technology are mutually dependent and different aspects of one great human achievement. Knowledge is power, and modern scientific technology is the inevitable incarnation of science in power. It is as meaningless and unprofitable to try to weigh them against each other in the balance as to ask: which is the more important, the seed or the flower? Without the right seed we will not get the right flower, but if we had no flowers I doubt whether we would attach much value to seeds.

It is, in fact, the very fruitfulness of science that has nourished its vitality and raised its prestige as an

intellectual activity, and this was admitted by Sir George Thomson. 'All the same,' he said, 'applications of science have a great importance. Not merely in the obvious way, but also as being a very clear and concrete proof of the truth of the ideas . . . the prestige which the more startling applications have given physics in recent years affects, and justly I think, popular regard for the ideas, and make the generality of educated men hesitate, at least, to hold views strongly opposed to them.'

This admission that the present prestige of physics is due to its more startling applications—which the engineer must put into shape before they are safe in the hands of the housewife—illustrates very clearly my previous point that the present unbalance of status and esteem, between science and applied science, is based on serious misconceptions and muddled thinking.

This wrong-headedness, where it exists, has most serious consequences in the schools and in all those who influence the young. In the universities we can do what we can to redress the balance, but this is not enough. I believe The Institution could render a great service, not incompatible with its high purpose, by a determined effort to promote the publicity, by all appropriate means, that is evidently necessary to drive home a truer sense of values. I believe such an effort to be necessary, not because engineers should be status seekers or put on airs, but because the welfare of the United Kingdom demands it.

ELECTRICAL-ENERGY PRODUCERS AND DISTRIBUTORS MEET

12th Congress of U.N.I.P.E.D.E. at Baden-Baden, 11th–14th October 1961

U.N.I.P.E.D.E.—the International Union of Producers and Distributors of Electrical Energy—held its 12th Congress at Baden-Baden, Germany, from the 11th to 14th October 1961. Over 500 representatives from 29 countries attended. This short report has been prepared by Mr. C. W. P. Orr, who attended the congress.

THE object of the congress, which meets every three years, was to discuss the work of its eight study committees since the last congress held in Lausanne. A large volume of paper, the combined weight of 43 special reports, had previously been circulated and was the basis of discussions concentrated into a period of 24 hours, quite inadequate to the flow of oratory provoked.

Nuclear generation

The discussion on nuclear generation revealed a greater awareness of the importance of economies of scale and of a high utilization. Both factors suggest that the most favourable situation for the introduction of nuclear generation is in large well-integrated systems where even the largest reactor will be but a small proportion of the total capacity. Such a system is likely to be in highly industrialized countries that are capable of providing the necessary facilities for rapid repairs and maintenance, thereby ensuring for the reactor a high availability. This represents a major change from past assumptions favouring nuclear generation for underdeveloped regions.

Mr. P. Briggs, speaking on behalf of Mr. F. H. S. Brown, observed that in Britain, a country almost entirely dependent on thermal power, there was no likelihood that the annual load factor on the present nuclear stations would fall. Their marginal cost would always be less than the cost of the best conventional plant, and, owing to the magnitude of the base load, some conventional plant would still be required for base-load duty. This happy circumstance was apparently not necessarily true in countries with important hydro resources, where seasonal conditions might provide excess spill energy.

Of special interest in the session on international connections was the news given by Mr. A. Dejou and Mr. L. Csuros that commissioning tests were then being conducted on the d.c. Channel cable between the United Kingdom and France and that the loading of the cables, designed for 160 MW, had already reached 140 MW.

Improvements and tariffs

A paper presented by Messrs. W. L. Parkinson, R. F. Campbell and R. Mills reviewed changes in the organization of both operation and maintenance staffs made necessary by the introduction of unit turbine/boiler plant of very large capacity. The section that created most interest was an account of the steps taken in Britain, initially at Keadby and Hams Hall, by improved planning, organization and supervision, to achieve the maximum reduction in the time required to complete annual plant overhauls.

Mr. Briggs and Mr. M. P. Henzell both emphasized from their experience at Ferrybridge, Stella and Kincardine the substantial savings that can be achieved by 'to the limit' working in the case of large base-load sets, where the replacement cost of generation is high. Mr. A. Matthews related the latest steps taken at Marchwood to reduce by 50% the cooling period for turbines, thus making a further substantial contribution to speedy overhauls.

The general discussion on the various papers submitted by the Tariffs Committee showed how far the industry had moved away from principles of charging what the traffic would bear. Mr. C. T. Melling, however, was at pains to show that, however attractive the principle of marginal costs, circumstances might arise where it was justifiable to offer tariffs that did not cover the marginal cost. Social reasons might demand tariffs below cost for rural areas; commercial reasons themselves might intervene for special industrial off-peak high-load-factor supplies where it could be expected

that within a short period the new plant to be commissioned (possibly nuclear) would have costs lower than the tariff. The essential point was that tariffs must be equitable; this called for clear judgment and a sound knowledge of marginal costs.

The rate of interest appropriate to consideration of investment and costing is always debatable. Mr. A. Puromaki reported on the novel practice of municipal authorities in Finland, for whom self-finance was important. The rate they adopted was apparently the mean of the growth rate of the undertaking and the commercial rate of interest, weighted respectively by the retained earnings and the loan capital.

Electrification and shorter hours

In the session dealing with the application of electricity, a paper was presented giving very complete and detailed statistics on domestic electrification in Europe. Saturation factors for the major appliances were shown to be rising rapidly, and ample scope remained for a further substantial increase.

Two main impressions remain of the discussion on the other papers. The first was the progress made, and still being made, in electrical methods of space-heating. Both Mr. E. Bates and Mr. J. W. Moule gave us news of the latest developments in the rapidly growing market for off-peak heating—an application that (like the Dagenham strike for a tea-break) still created surprise on the Continent. The second was the general acceptance by the industry in all countries of modern methods of sampling and, with certain precautions, of opinion polls to collect the basic information necessary for soundly devised commercial policies.

In the statistics session, an interesting discussion developed on the effect of the shorter working week. For several countries it was stated that the ratio of electricity output on Saturdays to that on full working days had fallen in recent years and had reduced the system load factor. For Britain it was said the Saturday/weekday ratio had shown no significant change during the past seven years. A reduction in hours was more likely to affect the normal time of starting and stopping work on the five working days. Cessation of work 25 min earlier each day could reduce the national peak load; on the other hand, a reduction of two hours on Friday afternoon would worsen the system load factor.

Statistics of electrical accidents, collated for several countries, revealed that two-thirds arose on consumers' appliances, and several speakers took this to indicate the need to improve the testing of equipment and referred to another paper dealing with installation regulation and safety inspection. The last two papers discussed the problem of diversity and multiple regression analysis and its application to the analysis of load curves.

Good progress made at C.I.S.P.R. meeting

University of Pennsylvania, 1st–5th October 1961

The Comité International Spécial des Perturbations Radioélectriques held its 15th plenary meeting in October 1961, in the United States. This report outlines the main work of the conference.

THE 15th plenary meeting of the C.I.S.P.R. was held at the University of Pennsylvania. This was the first time the conference had been held outside Europe. A not unexpected result was that the number of European delegates dropped sharply, but there was the compensation of a large United States contingent. It is gratifying to report the attendance of a strong and balanced British delegation of nine members.

Conference activities

This particular meeting marked the retirement of Mr. O. W. Humphreys as Chairman of the C.I.S.P.R., a position that he has held with distinction for the last eight years, and in fact the end of British chairmanship, the late Dr. S. Whitehead having occupied the position for the post-war years before Mr. Humphreys. The Secretariat remains British; it functioned with the unobtrusive efficiency that we have come to take for granted.

The conference was formally opened on the Monday morning with a speech of welcome by Dr. Chambers, Vice-President of the University of Pennsylvania, after which Prof. L. Morren of Belgium, who has long been active in the C.I.S.P.R., was unanimously elected Chairman.

After the opening plenary meeting the delegates divided into the three sub-committees—Limits of Interference, Measurement of Interference, and Impact of Safety Regulations on Interference Suppression—and the technical work of the conference began. The morning of the Thursday was spent in a technical visit, and in the afternoon the delegates were given the opportunity of a brief acquaintance with the attractions of Atlantic City. A meeting of the Steering Committee on Friday was followed by a validation meeting of the full Plenary Committee, and the proceedings ended with a dinner given by the American hosts.

The success of the new working groups

The 1961 meeting was noteworthy in that it had the benefit of the deliberations of the recently formed working groups, each consisting of a relatively small number of experts and dealing with specific aspects of the interference problem. These working groups, of which there are now eight, were formed after the 1958 meeting to increase the working efficiency of the conference.

The value of the working groups became obvious once the sub-committees had started their work, and there is no doubt that they were largely responsible for the substantial advances made towards the attainment of internationally agreed standards for the measurement and control of interference. In the conference itself one could detect a more urgent awareness of the importance of this aim and a greater readiness on the part of individual countries to modify their national regulations to conform with C.I.S.P.R. The possibility of Britain joining the Common Market might have been in the minds of some delegates; certainly there seemed to be a narrowing of the gap between the British and continental views on the degree of economic burden that it is fair to impose on an industry by the need to suppress interference.

Measurement of interference

The specifications for measuring apparatus for the frequency range 0·15–300 Mc/s have been firmly established, and in the not-too-distant future these specifications will no doubt be extended to cover the full frequency range for which C.I.S.P.R.-type apparatus is suitable, that is 0·015–1000 Mc/s. Some of the specification details for the artificial mains network used in the measurement of the r.f. voltages at the terminals of appliances remain to be worked out. The need for the development of heavy-current networks was recognized, in view of the increasing amount of industrial equipment needing suppression. There was strong support for the British practice of measuring terminal voltages with the V-network (B.S. 727) wherever possible, since the method is technically easier and more flexible than that using the delta-network, which however was retained for the comparatively rare occasions when the symmetrical component has to be measured.

The delegates at the closing plenary meeting of C.I.S.P.R.

Mr. O. W. Humphreys, the retiring Chairman, is in the middle of those seated in front of the middle table; Prof. L. Morren, the new Chairman, is seated second from the front at the left-hand table

One of the most important results in the measurement of ignition interference is the progress made towards reconciling the American method, which uses the peak meter, with the generally accepted C.I.S.P.R. method, which uses the quasi-peak meter. The quasi-peak meter is retained as the C.I.S.P.R. standard, but the working group on measuring equipment has been instructed to prepare specifications for other types of meter, especially the peak meter, and to determine the correlation between them. In the meantime, the conference felt emboldened to accept a practical correlation factor of 20 dB between peak and quasi-peak measurements of motor-vehicle ignition interference, which for the first time made it possible to convert American limits into C.I.S.P.R. equivalents and vice versa.

For many years the United Kingdom has been stressing the statistical nature of interference and the need to take this into account when testing appliances in large-scale production for compliance with limits. The conference has endorsed this view and has accepted the British proposals for sampling procedures.

On the thorny problem of discontinuous and low-repetition-rate interference and of what constitutes a 'buzz' or a 'click', the British definition of a buzz as a disturbance lasting longer than 0·2 sec was accepted, but the conference referred back to the working group, for further study, the problem of how the value of the tolerable limit is affected by the nature of the interference. The conference accepted the I.E.C. measuring technique for the local oscillators and time-bases of sound and television receivers.

The technique of measurement of power-line interference was established for frequencies up to 30 Mc/s, but the problem of correlating laboratory measurements with the interference fields from the lines themselves remains to be solved.

Limits of interference

The specification of limits of interference has always proved difficult, even when an agreed method of measurement has been established, and this conference made a major step forward when agreement was reached for motor vehicles and medical-diathermy apparatus and when good progress was made towards agreement for industrial r.f.-heating equipment.

A proposal to explore the practicability of allowing crystal-controlled equipment to operate over a very narrow frequency band on harmonics of 40·68 Mc/s was referred to the appropriate working group. It illustrates the change in outlook on suppression: a few years ago such a proposal would have been regarded as quite impracticable or as imposing an intolerable economic burden. A fair measure of agreement was reached on the values of the permissible limits for the radiation from the local oscillators of receivers and on the line time-base terminal voltages for television sets.

The impact of suppression on safety has largely been in connection with the problem of suppressing doubly-insulated appliances by bridging the insulation by a high-grade capacitor. The method does not command universal support, but as the alternative may sometimes involve the re-design of the appliance the matter has been referred back to the C.E.E.

Can C.I.S.P.R. be financed?

C.I.S.P.R. has sometimes been criticized for its apparent slowness in reaching decisions. Efforts to improve its efficiency

have been made over the years. The formation of steering and sub- committees and, recently, the working groups is evidence of this, but the fact remains that the C.I.S.P.R. has no funds of its own and therefore cannot directly engage in research. It can formulate study questions and make recommendations but can only appeal to national committees, which themselves have no executive power, for the essential research to be done.

This problem was very much to the fore in Mr. Humphreys's farewell speech at the final dinner. After reviewing the steps taken under his chairmanship to increase the efficiency of C.I.S.P.R., he ventured to 'throw out some ideas for his successor to pursue', the main one of which was the acquisition of funds under C.I.S.P.R. control and the establishment of an international laboratory to work on the interference problem. A visionary prospect, no doubt; but he was able to quote C.E.R.N. as a precedent.

W. NETHERCOT

ELECTRONIC AIDS TO BANKING

UNDER the aegis of the British Conference on Automation and Computation and in collaboration with the Electronics Sub-Committee of the Committee of London Clearing Bankers, the Electronics and Communications and the Measurement and Control Sections are organizing a symposium on electronic aids to banking, to be held at Savoy Place on the 17th–18th January 1962.

In addition to fast-operating mechanical sorters, British banks have taken steps to introduce modern electronic equipment, such as computers, automatic character readers and closed-circuit television, to cope with the growth of work connected with the handling of cheques and of credit vouchers. These steps will allow the banks to replace large-scale routine manual operations by high-speed automatic equipment.

The symposium is designed to provide a forum for bringing together experts from the banks and electronic engineers for fruitful discussion and exchange of views in order to help progress in a field of common interest. In the first session, representatives from the banks will explain their requirements, and, in the following sessions, engineers will discuss the methods and means available and the design effort to meet the requirements of the banks for automatic character-reading equipment and sorting of cheques, the use of computers for accounting, and the transmission of data over telecommunication links.

Symposium programme

Session 1.—Users' problems (17th January 1962, 10 a.m.)

Chairman—The President, G. S. C. Lucas, O.B.E.
Opening address by Sir Eric A. Carpenter, O.B.E., President of the Institute of Bankers
Introductory lecture by C. B. Howland, Chairman of the Electronics Sub-Committee of the Committee of London Clearing Bankers
Use of computers and electronic machines in banking by J. Letham (Bank of Scotland)
Document handling and character recognition by L. Temple (Lloyds Bank)
Accounting aspects in the use of computers by banks by R. Hindle (Martins Bank)
Communication aspects by J. G. Sauvage (Barclays Bank)

Session 2.—Document handling (2.30 p.m.)

Chairman—Dr. R. Feinberg, M.SC.
The reading of characters printed in magnetic ink by A. H. Cooper
Document-handling machines as an aid to banking by J. C. Vermeulen
High-speed document sorting from magnetic-ink characters by G. W. L. Davis
Document handling, character reading, automatic reading and sorting of cheques by E. Gordon-Perry

Session 3.—Accounting aspects and the use of computers (18th January 1962, 10.15 a.m.)

Chairman—W. S. Elliott, M.A.
The organization of a large banking computer centre by G. E. Deadman
Checks and checking features available on a particular computer by J. M. M. Pinkerton
Variable-word-length data-processing systems by I. A. Edmonds and A. C. D. Haley

Session 4.—Communication aspects (2.30 p.m.)

Chairman—R. J. Halsey, C.M.G., B.SC.(ENG.), F.C.G.I.
Data links for use with computers, with particular regard to applications in banking by H. G. McGregor Ross
Data transmission over telephone circuits and its application to large dispersed organizations such as banks by C. H. Wolff and F. Shore
Operational experience of a data link employing error codes for transmission by F. Beckett
An error-correcting system for data transmission on 50 baud telegraph circuits by R. E. Collis
A data communication system by S. Skoumal and P. Keller
The use of telegraph networks as a vehicle for high-quality data transmission by W. F. S. Chittleburgh and M. R. Ridler
Television document transmission by I. M. Waters and J. W. Gamble

SCOT–ICE TELEPHONE CABLE

THE cable ship H.M.T.S. *Alert* recently laid the northern sector of the Scotland–Faroes–Iceland (SCOT–ICE) submarine telephone cable. One of the functions of this cable will be to provide communication channels for the International Civil Aviation Organisation for its North Atlantic routes.

H.M.T.S. *Alert* sailed from Southampton on the 4th November and started laying operations on the 13th November 1961. The illustration shows repeaters being secured on board during loading of the ship.

The SCOT–ICE cable is a joint undertaking of the British Post Office, the Great Northern Telegraph Co. of Denmark and the Danish and Iceland Post and Telegraph Administrations.

621.375.1:623.454.2

Mechanized production of radio-proximity fuse amplifiers

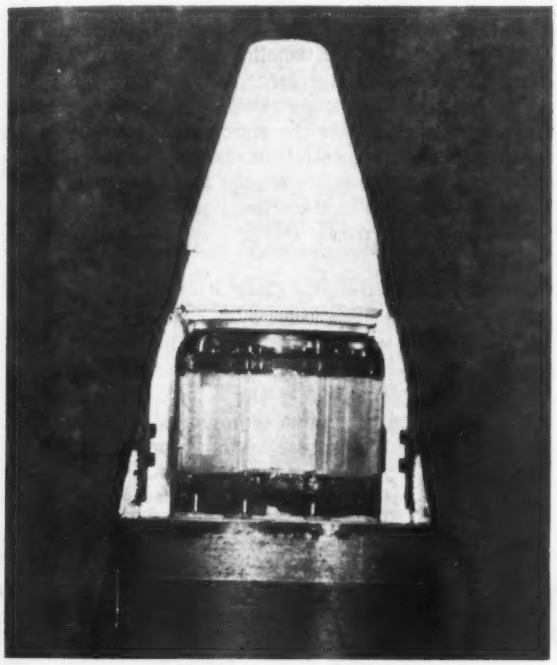
The British Armament Research and Development Establishment initiated a mechanization project with the object of mass-producing radio-proximity fuses to a high standard of uniformity and reliability. This article describes how the fuse amplifier was redesigned for automatic assembly and gives an account of the mechanized plant.

Mr. Woodham is at the War Office, Armament Research and Development Establishment, Sevenoaks, and Mr. Sykes is with the Plessey Co. Ltd., Ilford.

R. W. WOODHAM, A.M.I.MECH.E., ASSOCIATE MEMBER, and **N. W. SYKES,** M.A., B.SC.(ENG.), A.M.I.MECH.E., ASSOCIATE MEMBER

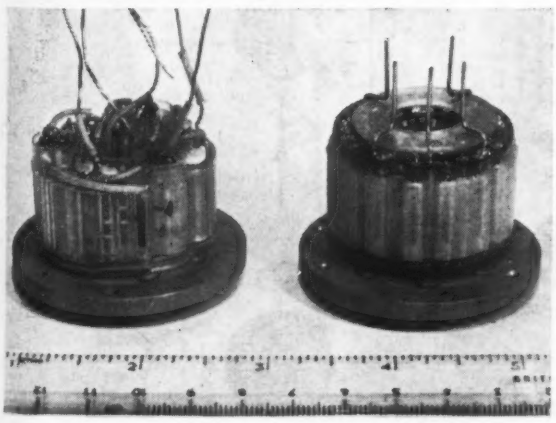
A radio-proximity fuse occupies the nose section of an artillery or anti-aircraft shell, and its function is to explode the shell when it comes within lethal range of the target. This small nose section (Fig. 1) must accommodate all the components required for a miniature radio transmitter and receiver, together with its own power supplies.

Apart from being extremely compact, the fuse has to be ruggedly constructed to withstand both the axial shock of firing, which may exceed 20000*g*, and the radial forces due to the spin of the shell in flight.



1 *Shell nose, showing electronic proximity fuse*

2 *Manually-assembled and mechanized amplifiers*



In the past, fuses were assembled and wired by hand, but the operations were slow and wiring errors often occurred. During the 1939–45 War, thousands of fuses were consumed each day, and it was obvious that some faster method of manufacture would have to be developed. Accordingly, the Armament Research and Development Establishment initiated a design study into the logistics of mechanized production.

The fuse in its conventional hand-assembled construction was not suitable for mechanization, and it was therefore redesigned in a more convenient form to make use of standard components and a special form of printed wiring, eliminating the need for large numbers of skilled operatives and ensuring a more consistent product unaffected by variations due to human error. Design effort was concentrated mainly on the fuse amplifier because this would show the greatest benefits from mechanization.

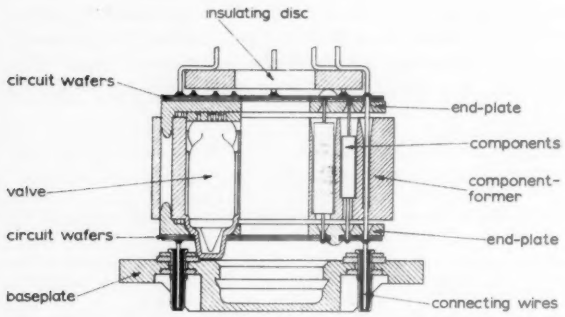
AMPLIFIER DESIGN

The hand-wired amplifier used a moulded polythene component-former to locate and support the amplifier valves and components; connections between components were made by sleeved wires and hand-soldered joints (Fig. 2).

The construction finally adopted for mechanization (Fig. 2) uses a modified polythene component-former and multi-layer printed-wiring end-plates.

A sectional view of the mechanized amplifier is shown in Fig. 3, and the component parts are illustrated in Fig. 4. Resistors, capacitors and rectifiers are loaded into the component-former holes in their correct positions. When a direct connection is required between the circuit end-plates, a length of solder-covered wire moulded into a polystyrene body is used to form a dummy resistor, which can then be handled in the same way as the other components.

Amplifier valves, which are of the subminiature flying-lead type, are prepared by adding a small polythene valve cap that supports the leads and converts the valve into what is virtually a plug-in unit. The polythene valve cap is provided with a locating key to ensure correct positioning in the component-former.



3 *Diagrammatic section of mechanized amplifier*

The wiring is printed on wafers. In order to obtain adequate connection points for soldering the component leads and to facilitate the lay-out of the printed conductors, additional space is obtained by adopting a multi-layer technique. This method overcomes the difficulty caused by crossovers, which are hard to avoid when printing a complex pattern within a limited area.

Printed wiring

In the mechanized-amplifier assembly illustrated in Fig. 3, the complete circuit wiring is printed on six wafers, three at each end. Provision is made in the assembly plant for printing four-, six- or eight-wafer amplifiers as may be required. Each wiring section is printed on 0·010in. phenolic-resin strip, and the three wafers at each end are superimposed one on the other on polystyrene end-plates. The wafers are located on rivet-like projections that are hot-formed after assembly to hold the wafers to the end-plates.

The main circuit is designed in such a way that direct electrical connections between the various sections of each triple assembly are not necessary. A proportion of the components are connected to each wafer, the outer and middle wafers having suitable clearing holes to allow access for soldering the joints occurring on the inner and middle wafers.

The polystyrene end-plates have holes with lead-in tapers to facilitate the feeding of the component leads through the holes in the wafers. These end-plates are secured to the component-former by means of three moulded projections that are an interference fit with corresponding holes in the component-former. A small gap is left between the end-plate and the former to allow potting material to enter, thus ensuring the complete encapsulation of the components and their leads.

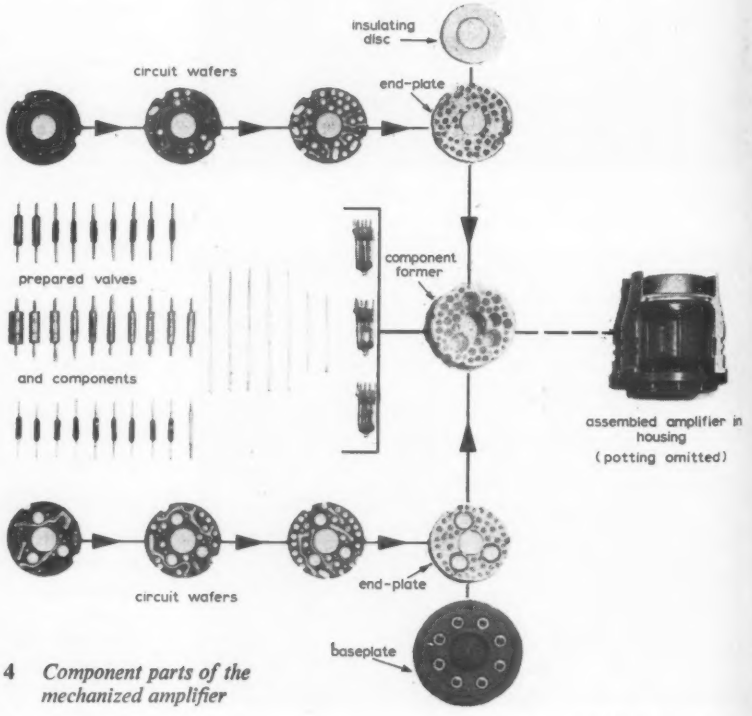
Interconnections between the amplifier, the baseplate and the oscillator are formed by lengths of solder-coated wire that are held in place during assembly by restrictions in the polythene former. The amplifier baseplate is soldered to the lower ends of these wires after the end-plate wafer assemblies have been dip-soldered. An insulating disc is placed over the top end-plate, and the wires are bent to the smaller pitch circle diameter required by the oscillator subassembly.

The amplifier is encapsulated in a polythene block that after shrinkage has the same shape and size as the housing cavity. A central recess in the baseplate is undercut to provide a key for the potting material. The baseplate is located in the metal housing by dowels and secured by hollow rivets.

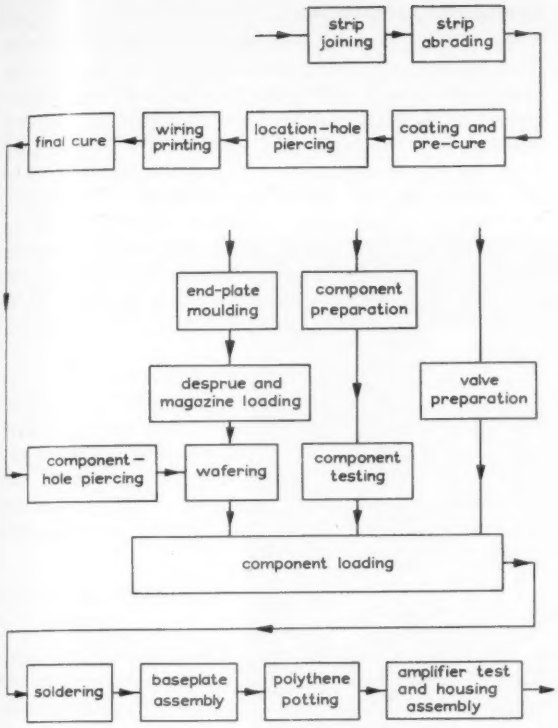
MECHANIZED-PRODUCTION PLANT

The specification required the mechanized-production line to be capable of producing 300 fuse amplifiers per hour and yet be sufficiently flexible to allow the introduction of modifications to the basic amplifier design.

It was decided that these requirements could best be met by breaking the process down into a series of major



4 *Component parts of the mechanized amplifier*



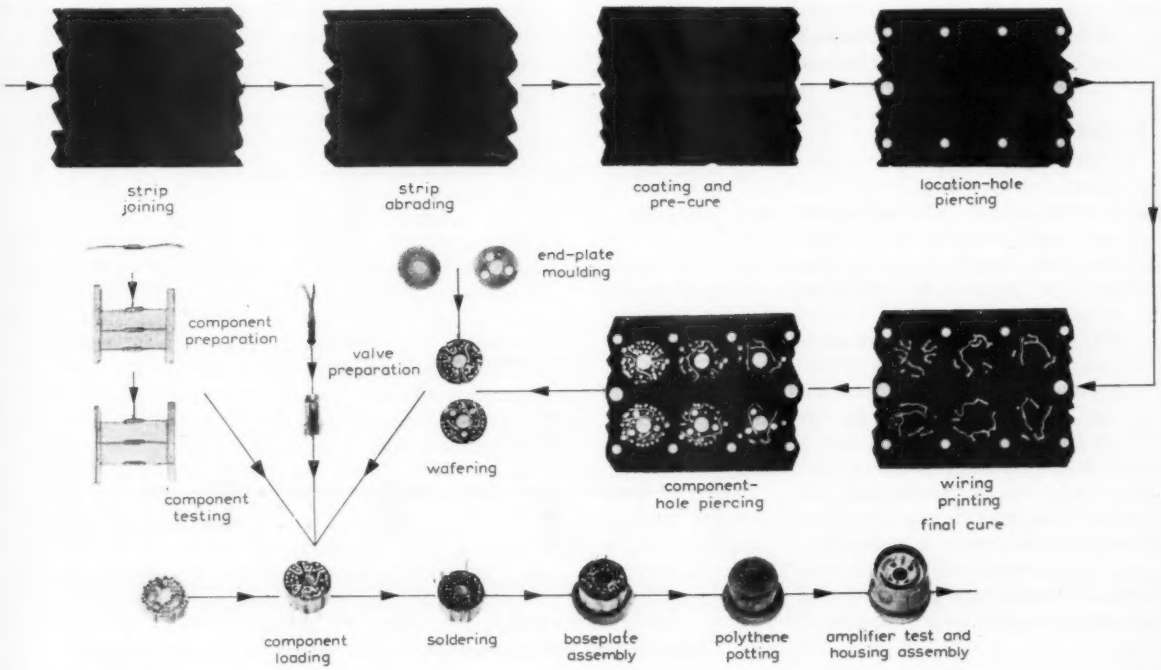
5 *The complete production line*

operations performed on separate independently powered machines, which could then be grouped together in the most convenient flow pattern. This method allows regrouping or the addition of further machines as modifications to the basic amplifier design necessitate. A further advantage is that each operation or series of operations can be performed at its optimum rate and need not be geared to match the speed of other operations. This allows stockpiling of components or subassemblies so that plant overhaul and tool replacement can be carried out without interrupting the complete assembly process.

On the other hand, to reduce the amount of manual handling, particularly towards the end of the line, it was found convenient to link together some of the machines and co-ordinate their control. This ensures that, once the amplifier former is correctly located, it can be transferred mechanically from one process to the next without manual relocation.

The complete production line comprises a series of 18 machines, shown in flow-diagram form in Fig. 5. The six machines in the first group perform the complete wiring-printing process. The four machines in the second group pierce and blank the circuit and complete the production of end-plate subassemblies. End-plate subassemblies and suitably prepared components and valves are assembled in the component-loading machine. The four machines in the last group solder the assembly, complete the interconnections and encapsulate the amplifier with polythene. A complete electrical test precedes final assembly into the metal housing. The progressive stages of manufacture are shown in Fig. 6.

6 *Progressive stages of manufacture*



Printing the wiring

The printing of wiring is considerably simplified by the use of 0·010in. phenolic material in roll-strip form. This material is available only in individual short lengths, which are joined to form strips 500ft long and 5in. wide, rolled on reels to facilitate handling. One surface of the strip is roughened by abrasion with carborundum grit to provide a key for the adhesive coating. This is applied to the strip in two uniform bands and partially cured by heating to remove tackiness before printing.

Master location holes, which are used in subsequent processes for indexing and registration, are pierced in the strip. The individual-strip length is chosen so that, however many circuit wafers an amplifier comprises, it is never necessary to print in the vicinity of a strip joint. To avoid the possible effect of cumulative errors, the location-hole piercing machine is designed to take a fresh datum from each strip joint. Sufficient overtravel is provided on the strip-feeding devices of subsequent machines to accommodate any slight corrections made at this point.

The complete wiring pattern, comprising in this case six wafers, is printed by a process that offers great advantages for mechanization over the conventional etched-copper-foil technique. Fine silver powder is spread evenly over the adhesive-coated surface of the strip; and a heated die bearing the raised image of the wiring pattern compacts the silver, under a pressure of almost 10 tons/in.^{2}, into the partially cured adhesive. Surplus silver powder is brushed off to be recovered, and the printed wiring is heated to cure finally the adhesive film. The silver conductors are now firmly and permanently bonded to the base material and are capable of withstanding large mechanical shocks.

Piercing and wafering

A 25ton press is used to pierce accurately, at one stroke, the 320 holes in the circuit pattern required for the component leads and the soldering-clearance holes in the outer wafers. The polystyrene end-plates are moulded in a six-cavity moulding-press, from which they are automatically transferred and de-sprued before loading into magazines for use on the wafering machine. In the wafering process the circuit wafers are blanked from the phenolic strip and automatically assembled and secured to the polystyrene end-plates. These printed-wiring subassemblies are given a complete electrical-continuity and insulation check and loaded into magazines for use in the assembly process.

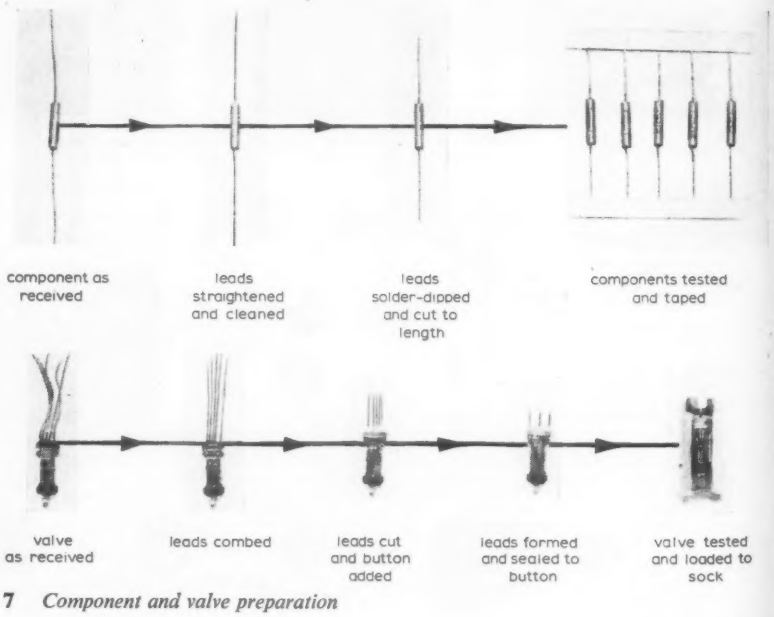
Component preparation

All the amplifier components are prepared before being electrically tested and mounted on tapes. Connecting leads are straightened, cleaned, and solder-dipped to facilitate automatic soldering (Fig. 7). It is expected that eventually all components will be supplied taped by the manufacturers, but at the time this work was done only one manufacturer would co-operate in this matter. Components supplied already taped are electrically checked in the component-testing machine, where a faulty component is marked by inserting into one tape a staple that is subsequently detected in the component-loading machine. That component is then rejected.

Miniature valves are prepared as shown in Fig. 7: the leads are combed, a plastic button is added to the base, and the wires, after being cropped and bent, are heat-sealed to this button. The valve is finally tested and inserted into a polythene sock for protection and to facilitate subsequent handling. These operations are performed automatically in the valve-preparation machine.

Final assembly

The prepared valves, components and interconnecting wires are assembled to the amplifier-former in the component-loading machine (Fig. 8). A bottom printed-wiring end-plate is attached to the component-former. As the assembly progresses down the line, up to 48 resistors, capacitors or rectifiers are loaded in groups of four at 12 loading stations. Each component is cropped from the tapes by an air-operated head and lifted by a solenoid into a loading breech. An air blast


component as received
leads straightened and cleaned
leads solder-dipped and cut to length
components tested and taped
valve as received
leads combed
leads cut and button added
leads formed and sealed to button
valve tested and loaded to sock

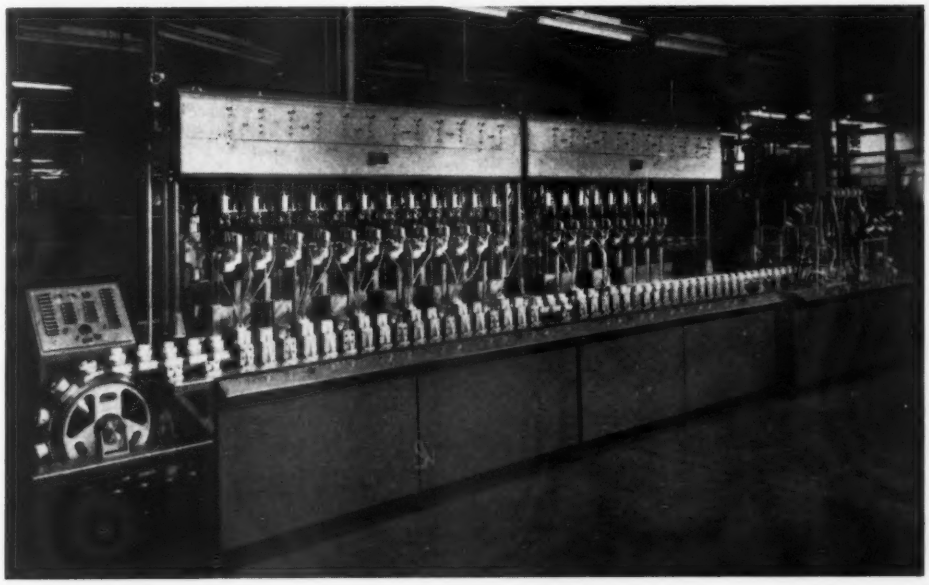
7 *Component and valve preparation*

propels the component down a plastic tube to the loading station, where the amplifier-former has been raised slightly to ensure correct registration. This action occurs simultaneously at all loading heads. If any component is faulty, the staple previously inserted in the tape causes that head alone to complete an additional cycle to reject the faulty component.

Each loading station is followed by a test station that checks the presence of correctly loaded components. The conveyor moves the component-former to the valve-loading section, which has provision for four valve-loading heads. Each head first positions a valve in its protective sock in a subsidiary indexing turret. The valve is electrically tested and, if satisfactory, indexed to a loading position, where it is pushed from the sock into the former below. A faulty valve is discarded, and that head alone continues to index until a sound valve is obtained for loading. Interconnecting wires are cropped from reels of solder-coated wire and fed to the amplifier-former by air-operated heads, after which the top end-plate wafer subassembly is added to complete the basic amplifier assembly.

Loading occurs at all heads simultaneously, and the machine is fully interlocked and sequentially controlled to give highest output. It has been designed to ensure reliability and to facilitate rapid fault-finding and maintenance: if any part goes wrong the machine automatically stops and the precise location and nature of the fault are positively indicated.

The assembled amplifier is passed to the soldering machine, where each end-plate wafer subassembly in turn is dip-soldered by a plunger method. The amplifier is supported over a well containing silver-saturated solder at 255°C; a cam-operated plunger working in an adjacent bore causes the solder to rise in the well and flow across the amplifier circuit. Clean solder is thus always brought into contact with the circuit, and the period of immersion and the rates of approach and withdrawal of the solder can be completely controlled. This has been found necessary to ensure fully reliable dip-soldering with a complete absence of bridging and solder tears in the confined areas between the printed wiring.



8 *Component-loading machine*

The soldered amplifier is assembled to the baseplate, the oscillator interconnecting wires are suitably preformed, and the assembly is encapsulated in polythene. Finally, the amplifier is given a complete electrical test and assembled into the housing.

PLANT ECONOMICS

In addition to the advantages of a more consistent and fully tested product from the mechanized plant, estimates show that considerable savings can be achieved in manpower, floor-space and costs. To produce 300 amplifiers per hour, a labour force of 13 would be required for the mechanized plant, which would occupy 1500 ft^2; an equivalent output by hand-assembly would need a labour force of 300 and a space of 20000 ft^2.

At a production rate of 300 amplifiers per hour, the estimated cost of assembly (labour and overheads) of the mechanized amplifier is reduced to less than two shillings. If the plant is run at well below capacity, the number of operators can be greatly reduced and the production cost will still show a saving over the cost of manual assembly.

Little retooling is required to produce a different amplifier, provided that the basic amplifier size remains unchanged.

Acknowledgments

The authors are grateful to their many colleagues for the parts they played in this project and to their superior officers for permission to publish this article.

Summary

The mechanization project had two main objectives: first, the maintenance of a consistently high standard of product quality and reliability and, secondly, the design and manufacture of a line capable of producing fuse amplifiers at a high rate with a minimum of skilled labour, yet flexible enough to allow the introduction of modifications to the basic amplifier design. To achieve these objectives it was found necessary to redesign the amplifier in a form more suitable for automatic assembly techniques. An extensive programme of trials established that the redesigned amplifier was rugged enough to withstand the enormous forces to which it is subjected during firing.

LETTERS TO THE EDITOR

A graphical method for determining slot constants
H. McKibbin, ASSOCIATE MEMBER

Watts and vars....F. T. Chapman, C.B.E., D.SC.(ENG.), B.SC., MEMBER; F. E. M. Hardy, ASSOCIATE MEMBER; P. P. Eckersley, MEMBER

The action of the single-phase induction motor
O. K. Gashus, B.SC., PH.D., GRADUATE

Hospital engineering...C. N. Anderson, ASSOCIATE MEMBER

Do you admire the view?.....K. L. Stretch, M.A., MEMBER

A construction for dividing tape on reels.....H. J. Burgess, B.SC.(ENG.), ASSOCIATE MEMBER

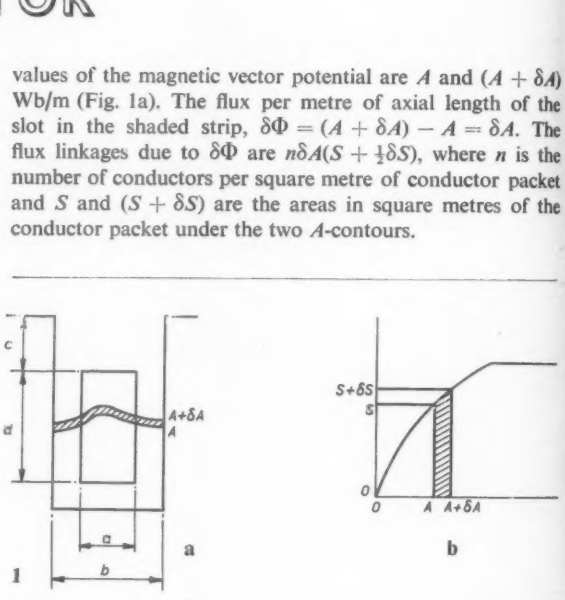
A GRAPHICAL METHOD FOR DETERMINING SLOT CONSTANTS

Dear Sir—I append a note on a graphical method for determining slot constants from flux plots, obtained by relaxation methods, which I have used for some years and which may be of interest to other members.

An approximation for the flux linkages $\mathscr{L}$ for one metre of axial length of an open rectangular slot may be obtained by assuming that the magnetic leakage-flux paths are straight and that no leakage flux exists below the conductor packet. This gives the expression $\mathscr{L} = \mu_0 i N^2 K$, where i is the current per conductor, N is the number of conductors per slot, and $K = (c + d/3)/b$ is the non-dimensional constant, which would be the same for all open rectangular slots having the same proportions (Fig. 1a).

While the assumptions of straight flux paths and no flux below the conductor packet are incorrect, it is fairly obvious that all geometrically similar slots will yield exactly the same leakage-flux configurations. This means that we may still use $\mu_0 i N^2 K$ to calculate the flux linkages per metre of axial length of a slot but the slot constant K will now have to be determined from the flux plot itself.

Consider two contours of the actual flux plot on which the values of the magnetic vector potential are A and $(A + \delta A)$ Wb/m (Fig. 1a). The flux per metre of axial length of the slot in the shaded strip, $\delta\Phi = (A + \delta A) - A = \delta A$. The flux linkages due to $\delta\Phi$ are $n\delta A(S + \frac{1}{2}\delta S)$, where n is the number of conductors per square metre of conductor packet and S and $(S + \delta S)$ are the areas in square metres of the conductor packet under the two A-contours.



1

If a graph is drawn of 'areas of conductor packet under the magnetic-vector-potential contours' against 'magnetic vector potential', the S/A graph (Fig. 1b), it will be seen that the flux linkages due to $\delta\Phi$ are equal to n times the shaded area in Fig. 1b. Therefore $\mathscr{L} = n$ (area under S/A graph), and $K = n$ (area under S/A graph)$/\mu_0 i N^2$. Up to this point the analysis has been carried out dimensionally, but this is unnecessary, as will now be shown.

Let the mesh length of the square-meshed net, used to obtain the flux plot, be h m, to the full-size scale of the slot. If, instead of the area of conductor packet under an A-contour, the number of meshes m under the contour is plotted against A, then $\mathscr{L} = nh^2$ (area under m/A graph). We may write $ni = J$ A/m^2, and if any convenient constant C is used instead of $\mu_0 h^2 J$ (see below) in the residual equations for nodes inside the conductor packet, then $\mu_0 i = C/nh^2$. Further,

if M is the total area of the conductor packet in meshes, $N = nh^2M$, so that $\mu_0 iN^2 = Cnh^2M^2$ and $K =$ (area under m/A graph)$/CM^2$.

A convenient practical procedure for determining K is:

1. Obtain a relaxation solution using any convenient constant C instead of $\mu_0 h^2 J$ (see below) in the residual equations
2. Use a mesh length of $h = 1$ in. to draw the slot and its leakage field to scale
3. Determine (e.g. by planimeter) the area of conductor packet under each A-contour in square inches; these areas will be numerically equal to the number of meshes m below each A-contour, since $|h^2| = |1|$
4. Plot the m/A graph
5. Determine the area under the m/A graph (X units, say)
6. Then $K = X/CM^2$, where M is numerically equal to the total area of the conductor packet in square inches of the scale drawing.

It is easily shown that the use of C instead of $\mu_0 h^2 J$ in the conductor-packet residual equations has no effect on the final result. If J is in amperes per square metre, h is in metres, and A is in webers per metre, then, in the M.K.S. system, the residual equation for a node of a square-meshed net with four full-length arms emanating from it is $F_0 \equiv A_1 + A_2 + A_3 + A_4 - 4A_0 + (\mu_0 h^2 J)_0 \simeq 0$. Suppose that, for computational convenience, the term $(\mu_0 h^2 J)_0$ is multiplied by some factor k. The resulting residual equation will be $F_0' \equiv A_1' + A_2' + A_3' + A_4' - 4A_0' + (k\mu_0 h^2 J)_0 \simeq 0$, where $A' = kA$; that is to say, the resulting solution will be k times the M.K.S. solution. Also, the area under the m/A' graph will be k times the area under the M.K.S. m/A graph, but since $C = k\mu_0 h^2 J$ the multiplying factor k cancels out when $K = X/CM^2$ is evaluated.

In conclusion I would point out that the example of the rectangular slot has been used merely for simplicity. The method can be used for any slot shape without further complication.—Yours faithfully,

H. McKIBBIN

The Nigerian College of Technology
Department of Electrical Engineering
Zaria Branch
Zaria, Nigeria, W. Africa

14th October 1961

WATTS AND VARS

Dear Sir—If a supplier of electricity, A, provides a single-phase supply at voltage $v = V_m \sin \omega t$ to a consumer, B, who takes a current with a reactive component $i' = I_m' \sin(\omega t - \pi/2)$, the relevant phenomenon occurring in the mains is fully represented by the equation $vi' = \frac{1}{2} V_m I_m' \sin 2\omega t$. This indicates an oscillation of energy between the two parties with a periodicity $2f$. If V and I' are the r.m.s. values of v and i', then $vi' = VI' \sin 2\omega t$, since $VI' = \frac{1}{2} V_m I_m'$, and if we give the name vars to VI' it follows that vars and watts are identical *in this context*.

More usually, however, when we speak of a supply of 'reactive power', or of vars, we do not refer to individual oscillations, but we have in mind a continuous train of these oscillations extending over some hours, in the course of which the parties A and B take it in turns to supply energy to each other in equal quantities. The position of A differs from that of B in that he supplies the mains and other equipment that must carry the wattless current involved and is thereby put to expense, which justifies him in making a charge against B on this account for a *service* that he renders. This service is of value to B because it provides him with facilities for the storing and restoring of energy in the magnetic fields of his transformers and other a.c. equipment; he is therefore willing to pay A's charges (which are in the nature of rent).

The important point is that, although energy is the medium in which this transaction is carried on, the commodity that is bought and sold, to which Prof. R. O. Kapp refers in his last letter, is *service* (November 1961 *Journal*, p. 662). If we say that A supplies 'reactive power' to B and use the symbol VAr for it, we must remember that B does the same to A; by using the symbol VAr for the commodity that A does in fact supply we are applying it, *in this context*, to something non-physical, which does not qualify it for dimensions.

The so-called reactive-power meter provides a useful basis on which A's charges can be assessed, but its reading depends on the product of a voltage in one circuit and a current in another, and this does not necessarily mean (*pace* Prof. Kapp) that its registrations indicate a physical reality; it is, in effect, an analogue computer.

An analogy may be drawn with a bank and its customers. Their transactions are in the medium of money, but the bank charges the customers for *service*, not for money.—Yours faithfully,

F. T. CHAPMAN

20 Freta Road
Bexleyheath, Kent

20th October 1961

Dear Sir—As electrical engineers we have been exposed at an early stage to the use of rotating vectors to represent alternating quantities. It is pedantic to use the whole rigmarole 'the instantaneous value of the quantity is equal to the projection of the rotating vector on the j-axis'. We use the phrase 'voltage (or current) vector', and, with the use of complex algebra, we achieve a formally consistent notation. In so doing, we give current and voltage, both scalar quantities, the status of vectors. Having done so, we gratuitously introduce the projection on the 1-axis and call it a quadrature component.

I suggest that (a) the single rotating vector gives an over-simplified mathematical model, (b) Ferraris's principle, involving two counter-rotating vectors (and in which the quadrature components cancel) is the more correct model (even though its rigorous application would involve a novel and much more cumbersome algebra for the statement of simple circuit theory), and (c) while power (watts) is a real quantity, volt-amperes and vars are fictitious, since neither can be derived from functions of instantaneous voltage and current for the same instant.

In support of (c) I would quote the ease with which power may be measured (the complexities of the wattmeter arising only from material imperfection such as friction and hysteresis), whereas measurement of volt-amperes and vars

involves either much elaboration or the acceptance of often subtle assumptions concerning symmetry of polyphase voltages. Volt-amperes is a convenient sort of portmanteau quantity, useful for indicating the capacity (and cost) of plant and circuits, as it includes both current and voltage, which must be provided for separately in the design. Vars follow by analogy.

I do not see how one can object to saying 1[watt] = 1[VA] = 1[VAr], provided that it is clear that this is a dimensional equation, and nothing more. Whether the statement is particularly helpful is another matter. In railway-traffic statistics, 'ton-miles' is encountered, but there would be few who would be willing to develop any very profound theory from the formal similarity of the dimensions of this quantity to those of energy.

In spite of the foregoing, I shall continue to use and teach the use of volt-amperes and vars.

I have always found the theory of dimensions unsatisfactory in that quantities that are different in kind have the same dimensions. The classic example, of course, is energy and torque. I suggest that this anomaly can be cleared up by the introduction of a scalar/vector dimension. Of the fundamental dimensions, mass, time and charge (and °C) are scalar and length alone is a vector. The term 'product' in mathematics is used to mean the result of multiplying a scalar or a vector by a scalar, or a vector by a vector, which last may be either the scalar ('dot') product or vector ('cross') product. The suggested innovation is that the dimension of length be $[j][L]$, where the $[j]$ indicates its vectorial nature, and that for 'multiplications' or 'divisions' giving rise to vector products an additional $[j]$ be introduced. Thus the dimensional equation for work becomes:

$$[\text{work}] = \{[j]^1[M]^1[L]^1[T]^{-2}\}\{[j]^1[L]^1\} = [-1]\{[M]^1[L]^2[T]^{-2}\}$$

the absence of a term in $[j]$ indicating that it is scalar, for torque:

$$\begin{aligned}[\text{torque}] &= \{[j]^1[M]^1[L]^1[T]^{-2}\} \times \{[j]^1[L]^1\} \\ &= [j]^1.\{[j]^1[M]^1[L]^1[T]^{-2}\}.\{[j]^1[L]^1\} \\ &= [-1]\{[j]^1[M]^1[L]^2[T]^{-2}\}\end{aligned}$$

Similarly, angle, instead of being dimensionless, is now seen to have dimensions $[j]^1.\{[j]^1[L]^1\}/[j]^1[L]^1$ or $[j]^1$—Yours faithfully,

F. E. M. HARDY

Abadan Institute of Technology
22nd October 1961 Abadan, Iran

Dear Sir—I postulate an alternator driven through a virtually lossless mechanical transmission from a capstan, also a changeover switch connecting the terminals of the alternator either to a resistor R or a reactor.

The resistance of R would be chosen so that R absorbed as much power as would require the capstan to be fully manned and yet would be large compared with the internal impedance of the alternator. The reactor, having a large Q-factor, would have a reactance equal to the resistance of R.

A team of those who deny a difference between watts and volt-amperes would be set to work on the capstan, the alternator being connected to the resistor. When they were out of breath with pushing and singing their shanty 'heave awa' and watts a var', the switch would be instantaneously changed over, the reactor being substituted for the resistor.

I should expect, as a result, an undignified sprawl of heretical opinion; would I be right in this surmise?—Yours faithfully,

P. P. ECKERSLEY

53 Hasker Street
8th November 1961 London S.W.3

THE ACTION OF THE SINGLE-PHASE INDUCTION MOTOR

Dear Sir—Prof. F. C. Williams and Dr. E. R. Laithwaite in their article 'The action of the single-phase induction motor' in the September 1961 *Journal*, p. 550, call attention to an important issue. However, on their point of 'the confusion between X_L and X_m' they fail to resolve the confusion and, if anything, provide two wrong formulas instead of one.

Starting from the equivalent circuit as given in Fig. 3 of the above article, it follows without any simplifications that the torque is given by:

$$T = kI^2\left[\frac{\sigma\dfrac{R_2}{X_m + X_{2L}}}{\left(\dfrac{R_2}{X_m + X_{2L}}\right)^2 + \sigma^2} - \frac{(2-\sigma)\dfrac{R_2}{X_m + X_{2L}}}{\left(\dfrac{R_2}{X_m + X_{2L}}\right)^2 + (2-\sigma)^2}\right] \quad \text{(a)}$$

where k is a constant. Consequently, by the equation $T = 0$ we obtain the following solutions for σ:

$$\sigma = 1 \text{ and } \sigma = 1 \pm \sqrt{\left[1 - \left(\frac{R_2}{X_m + X_{2L}}\right)^2\right]} \quad . \quad \text{(b)}$$

The correct no-load speed is therefore given by:

$$\omega = \pm\,\omega_s\sqrt{\left[1 - \left(\frac{R_2}{X_m + X_{2L}}\right)^2\right]} \quad . \quad . \quad \text{(c)}$$

This differs from both equations (4) and (5) as given in the article and, therefore, affects the conclusions reached on the basis of eqn. (5). In fact, the assertions that $R_2 < X_m$ and that $R_2 < X_{2L}$ are necessary conditions in order to obtain a useful machine are both too stringent. If X_m and X_{2L} are of the same order, the correct no-load speed must obviously be derived from eqn. (c) rather than any other.

Again, if $X_{2L} \simeq X_m$, the conclusions reached for the minimum size of drag-cup rotor are also wrong. This seems quite likely to be so in the small size of motor discussed, and it would be interesting to find out how the figures quoted compare with practical results.

A point of interest to lecturers is the use of counter-rotating fluxes to simulate a pulsating flux. Unfortunately, it has sometimes been stated that this is shown by the identity:

$$\cos \omega t = \tfrac{1}{2}(\varepsilon^{j\omega t} - \varepsilon^{-j\omega t})$$

the right-hand side illustrating the two 'rotating' components. Of course, this identity shows nothing of the sort, since the travelling waves are not shown at all. A space distribution is essential to the argument, and it is therefore important to include this in any illustration of the procedure. Fig. 1b is not entirely satisfactory, because it needs a forceful reminder of what the vectors are in fact representing.—Yours faithfully,

O. K. GASHUS

Department of Electrical Engineering
The University
23rd October 1961 Glasgow W.2

[Prof. F. C. Williams and Dr. E. R. Laithwaite write: Every theoretical analysis of a practical machine makes approximations and can therefore be said to be 'wrong'. In this respect and in this respect alone, Dr. Gashus is entitled to say that we have produced two 'wrong' formulas. Of these two equations, one was introduced specifically because it *was* wrong, and his remarks, therefore, have relevance only to eqn. (5). The latter follows at once from his eqn. (c) by putting $X_{2L} = 0$, and we took this step to emphasize the importance of X_m. We agree that, if one uses a detailed equivalent circuit such as the one we gave without approximation, one will arrive at an answer which is correct to that degree of detail, and this he has done in his eqn. (a).

It was not our intention to derive accurate formulas for the performance of the single-phase induction motor. There are many papers devoted to this subject. What we have done is to point out a common fundamental error in the presentation of the subject and a common confusion between the roles of X_m and X_{2L}. By neglecting X_{2L} we avoid a difficulty that arises with eqn. (c), which suggests that the machine would run with $X_m = 0$ if X_{2L} were sufficiently large, which is equivalent to saying that a stator in Manchester will rotate a rotor in Glasgow.

With regard to the comment on the minimum size of drag-cup rotor, X_2 cannot, with any reasonable geometry, approach the value of X_m, as is shown in L. S. Piggott's recent paper on induction machines (PIGGOTT, L. S.: 'A theory of the operation of cylindrical induction motors with squirrel-cage rotors', *Proceedings I.E.E.*, Monograph 490U, December 1961 (**109**C)).

Dr. Gashus's last comment does not appear to be related very closely to the article. We would only add that lecturers are ill-advised to speak of pulsating fluxes at all in connection with rotating machines, except in very special circumstances.]

HOSPITAL ENGINEERING RESEARCH UNIT

Dear Sir—I hasten to join the lists in tilting at the short article in the October 1961 *Journal*, p. 608, which might give the impression to the uninitiated that hospitals are planned haphazardly. The anonymous author goes further and states that the maintenance of engineering services in hospitals is given little thought at the design stage. If the author had qualified his statements to the effect that the findings applied to the older job, I might have agreed with him.

Your readers may not be aware that chartered engineers are employed directly by the various Regional Hospital Boards in the United Kingdom and, indirectly, in firms of consulting engineers meeting with architects and planners on equal terms; and I am quite sure that my professional colleagues in other Regions would join with me in assuring you that much thought is given to the points criticized. New approaches are indeed welcome on any project, and the results of surveys such as are being undertaken by the Nuffield Unit are eagerly awaited; but general and sweeping statements, such as you have published anonymously, are dangerous and are apt to give a wrong view of the picture as a whole.—Yours faithfully,

C. N. ANDERSON

Deputy Regional Engineer
Western Regional Hospital Board
351 Sauchiehall Street
25th October 1961 Glasgow C.2

DO YOU ADMIRE THE VIEW?

Dear Sir—The Foreword in the October 1961 *Journal*, p. 587, suggests that the only objections to the Central Electricity Generating Board's Supergrid plans are aesthetic, and ignores technical and economic reasons for preferring other methods of transporting energy in bulk.

It is difficult to follow the logic of your argument that locating power stations on the coalfields, where alternative supplies of fuel are difficult and costly, cushions industry against rising coal costs. Even the claim that this minimizes transport costs involves the unjustified practice of equating the cost of transport of fuel with that of distributing energy. This is the very point where C.E.G.B.'s own analysis is defective, as they compare the transport of energy as coal by rail on an obsolete railway system with the most modern developments in electrical transmission (BROWN, F. H. S.: 'The power system', *Journal of the Royal Society of Arts*, 1960, **108**, p. 690). If, instead, one compares electrical transmission with the bulk transfer of energy in chemical form by pipeline, the advantage, if anything, lies with the latter for the loads and distances involved between control areas in this country.

In addition, considerable operational advantages would flow from a policy of distributing the coal in bulk by efficient modern methods and locating the base-load stations near to their base loads. More coal-fired stations could enjoy the advantages of tidal cooling without having to be located in amenity areas for safety reasons, thus obviating the need for unsightly cooling towers and reducing the heat load on the overburdened Trent.

Moreover, as a coal-distribution system would work to stock instead of immediately to load, temporary troubles on the system would not be immediately reflected in the danger of interruption of supply to consumers. The commitment of a large section of the Grid to bulk transfer in one direction

is going to either reduce seriously its primary insurance value or make nonsense of the high load factors postulated in making it appear economically attractive.

The alternative to the Supergrid is not underground electrical transmission but the bulk distribution of coal, oil and gas by pipeline. Not only amenity, but also economic development and operational reliability, are being prejudiced by a scheme propounded without adequate consideration of the full range of alternative solutions or an accurate assessment of the real cost of each.—Yours faithfully,

K. L. STRETCH

College of Advanced Technology
Gosta Green
30th October 1961 Birmingham 4

[In addition to electrical transmission and the transport of coal by rail or road, there is the pipeline method of transporting power. This method could be used to supply fuel for power stations, either by pre-gasification of the coal or by transporting the coal as a slurry. The cost of gasification is at present prohibitively high, and although research work is being done this possibility does not hold out great promise. We understand that the C.E.G.B. are doing both small-scale and large-scale research on pipeline transport of coal. A good many problems are involved, and they believe that, if these are overcome, the method might find application to short hauls in the initial stages, but it is doubtful whether it could be applied to long-distance transport within the foreseeable future.—Editor]

A CONSTRUCTION FOR DIVIDING TAPE ON REELS

Dear Sir—Your readers may be interested to know that Mr. F. N. Scaife's construction described in the July 1961 *Journal*, p. 432, especially as extended by Mr. P. D. Hanstead in the September issue, p. 560, will be useful in the timber industry. For example, veneer logs often have to be divided into outer and inner regions for face veneer and 'core stock' in given proportions, after excluding the central region occupied by the chucks or by defective timber. For saw logs it is often useful to know what proportion of the usable volume (excluding a defective core) is occupied by the sap-wood band.

Especially taking into account Mr. E. Janmoulle's letter in your September issue, p. 560, this correspondence is a relatively trivial but convincing example of the need for more 'all-rounders' to provide liaison between different fields of study; we are nearly all specialists these days, and very few of us have much idea of what is going on in fields outside our own.—Yours faithfully,

H. J. BURGESS

Forest Research Institute
Kepong, Selangor
31st October 1961 Federation of Malaya

MEETING OF THE INSTITUTION COUNCIL ON THE 2nd NOVEMBER 1961

THE following summary of reports received and decisions reached by the Council of The Institution at their meeting on the 2nd November 1961 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meeting, since some items are to be the subject of further discussion by the Council.

Resignation of an elected member of Council

The Council accepted with regret the resignation of the seat of Dr. J. Brown; he had been elected as an Associate Member from the 1st October 1961 but would be unable to continue to serve as he would be leaving England at the end of January 1962 to take up an appointment as a professor in the new Delhi Engineering College. The General Purposes Committee were asked to consider the filling of the casual vacancy on the Council thus created.

Institution Conversazione

With reference to the next Institution Conversazione, which the Council at their last meeting had agreed should take place at the Royal Festival Hall, London, on Thursday, 5th July 1962, a recommendation from the Finance Committee was accepted that the price of tickets to members and their guests should be increased by 2s. 6d. to £1 17s. 6d. except that Students and Graduates under the age of 28 should be able to obtain a single ticket for £1 or a double ticket for £1 15s. as on the previous occasion.

Representation of The Institution on other bodies

On the recommendations of the General Purposes Committee, the Education and Training Committee and the Examination Committee, the Council appointed representatives of The Institution to serve on a number of other bodies. Details of these appointments will appear in the January 1962 *Journal*.

British Conference on Automation and Computation

The Council were pleased to receive the thanks expressed at the Annual General Meeting of the British Conference on Automation and Computation, held on the 27th September 1961, for the secretarial services provided by The Institution, and gave their consent to the appointment of Mr. F. Jervis Smith, Deputy Secretary of The Institution, as Honorary Secretary of the B.C.A.C.

Science Museum—Electrical Communications Collection

In response to a request from the Director of the Science Museum, it was agreed on the recommendation of the General Purposes Committee that The Institution should co-operate in the development of an Electrical Communications Collection on the lines of the Electrical Power Collection already in the Museum.

National Productivity Year

On the recommendation of the General Purposes Committee, the Council agreed that The Institution should lend its support to the National Productivity Year that the British Productivity Council are proposing to arrange for 1962–63. Ways in which The Institution could particularly help were by co-operation with local British Productivity Council units, and by independent activities, in the local Centres and by publicizing in the *Journal* the objects and programme of the National Productivity Year.

British Association for the Advancement of Science

Consideration had been given by the General Purposes Committee to a proposal from the British Association for increased co-operation between the various societies operating in the Provinces, involving the creation of local branches of the British Association. The Committee, after consulting the Local Centres Committee, put forward a recommendation, which was accepted by the Council, that the British Association be informed of The Institution's support for its proposal.

International symposium on rationalization of the use of electrical energy

An invitation had been received from the Association of Polish Electrical Engineers for The Institution to send one or more representatives to the above symposium, to be held in Warsaw in May 1962 under the auspices of the United Nations Economic Commission for Europe. The Council, on the recommendation of the Papers Committee, decided to invite Dr. T. E. Calverley, B.SC.(ENG.), MEMBER, and Mr. H. Jackson, B.SC.(ENG.), MEMBER, to represent The Institution at the symposium.

International telemetering conference

Following informal discussions between representatives of The Institution and the American societies responsible for the organization of the national telemetering conferences that are held annually in the United States, the Council, on the recommendation of the Papers Committee, supported a proposal that The Institution should, with the American societies concerned, act as joint sponsors of an international telemetering conference to be held in London in September 1963.

Committee on Higher Education

The Council had before them a revised draft of the memorandum to the Committee on Higher Education, which had been modified by the Education and Training Committee to take into account the views expressed at the last Council meeting (November 1961 *Journal*, p. 659). It was believed that both The Institution of Civil Engineers and The Institution of Mechanical Engineers were contemplating some modification of the draft, and the Council hoped that a common document could be produced.

They approved the revised document in principle and decided that Mr. S. E. Goodall, who, as the representative of the Council, would meet the Committee on Higher Education to submit oral evidence, should endeavour, after consultation with the Education and Training Committee, to achieve a joint submission without unduly weakening the present document.

Should this not be found possible, the Council agreed that the revised document should be submitted to the Committee on Higher Education as a memorandum from The Institution alone.

It was noted that in any case it was proposed that The Institution itself should submit a separate memorandum, on the subject of research in the universities and colleges of advanced technology, which was in course of preparation by the Education and Training Committee.

Atlantic telegraph cable, 1866

The Council accepted with pleasure an offer from Maj. A. C. Kennedy, MEMBER, to present to The Institution a small show-case containing short lengths of sections of the Atlantic telegraph cable, 1866, and directed that their appreciation be conveyed to Maj. Kennedy.

Oversea Representative for the Middle East

The Council approved the appointment of Mr. A. Ainscough, ASSOCIATE MEMBER, as the Oversea Representative of the Council for the Middle East in place of Mr. H. D. Furber, MEMBER, who was returning to the United Kingdom.

CONSOLIDATION OF A.I.E.E. AND I.R.E.

THE American Institute of Electrical Engineers and the Institute of Radio Engineers are considering consolidation of the two Institutes. A committee has been formed, in accordance with a resolution passed by the Boards of Directors of both Institutes, 'to determine the feasibility, practicability and form of such consolidation'. The committee is to report to the Boards not later than the 15th February 1962, for their approval 'with a view to submission to a vote of the memberships of the two Institutes and consummation, if so approved, by January 1, 1963'. The proposed new organization would have 150000 members.

The resolution pointed out that 'the advancement of the theory and practice of electrical and radio engineering and the educational and scientific objectives of both Institutes may be better served by merger or consolidation . . . into one organization in which all present members would be included, and in which they would enjoy the same rights and privileges now conferred on them by their separate organizations'. The Boards of Directors deem it advisable, the resolution said, 'to move actively toward the consolidation of the activities and organization' of the I.R.E. and the A.I.E.E., 'by consolidation or otherwise, provided that the legal and operational problems incident to such consolidation can be satisfactorily resolved'.

The committee appointed is authorized to prepare a proposed constitution and bye-laws 'in consultation with representatives' of both Institutes.

The experimental investigation of space

621.396.946:621.391.812.63

Experiments carried out in rockets and satellites during the past few years have already contributed greatly to our understanding of the upper atmosphere and of conditions in interplanetary space and have provided valuable new data for the study of the sun and sun–Earth relations. This article is based on a lecture delivered on the 18th May 1961 at Savoy Place, after the Annual General Meeting. The author is Director of the Radio Research Station, Slough.

J. A. RATCLIFFE, C.B.E., M.A., F.R.S., MEMBER

THE words 'space science' are freely used in several contexts, not all of them strictly scientific. In this article they will be taken simply to mean the study of what is outside the Earth by means of experiments made in rockets and artificial satellites. The purpose of the article is to show why this kind of science is important and to give illustrative examples of the results obtained.

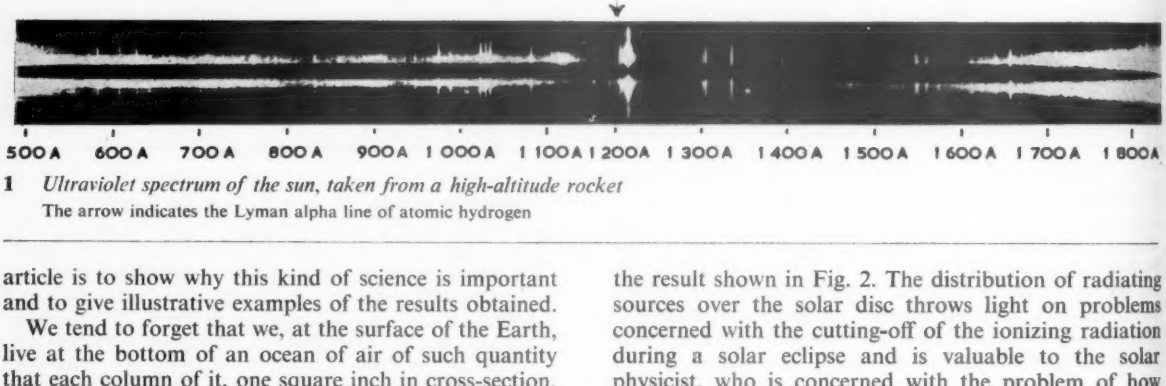
We tend to forget that we, at the surface of the Earth, live at the bottom of an ocean of air of such quantity that each column of it, one square inch in cross-section, weighs 14lb. There is, for example, so much of it that the weight of air under an ordinary table is about 2 lb. This overlying atmosphere absorbs many of the electromagnetic radiations (light, X-rays, ultraviolet) and particle radiations that impinge on it from outside, so that we cannot observe them. For many purposes it is the mass of gas that is important in the absorption process, and on a mass-for-mass basis it is as though we lived at the bottom of an ocean of water 35 ft deep, and hoped to know all about the radiations that were falling on it at the top.

Radiations outside the atmosphere

The atmosphere, held to the Earth by gravity, becomes more and more tenuous the higher we go, and it can be said, roughly, that its density decreases by a factor of ten for every 20km increase in height, so that at a height of 120km it is reduced to 10^{-6} of its value at the ground. For the detection of all except the most absorbable radiations, it can be said that at this height a piece of apparatus is outside the atmosphere.

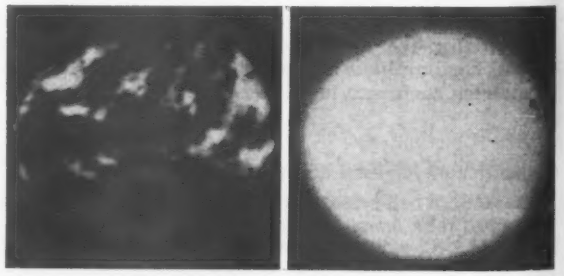
Rockets carrying equipment to heights of this order have provided some most interesting information. For example, a picture of the ultraviolet spectrum of the sun, taken from such a rocket, is shown in Fig. 1. A spectrum of this kind would be quite unobservable through the atmosphere, which completely absorbs all wavelengths less than about 2900Å. The spectrum is of interest to the solar physicist, who has to account for the observed lines, and to the ionospheric physicist because it shows him what wavelengths are available for ionizing the atmosphere and what are their intensities.

The strong line marked by the arrow on the Figure near 1200Å is particularly interesting. It is the Lyman alpha line of atomic hydrogen, and it is important in the production of the ionosphere. It has been possible to photograph the sun from a rocket in the light of this line, with the result shown in Fig. 2. The distribution of radiating sources over the solar disc throws light on problems concerned with the cutting-off of the ionizing radiation during a solar eclipse and is valuable to the solar physicist, who is concerned with the problem of how it is radiated.



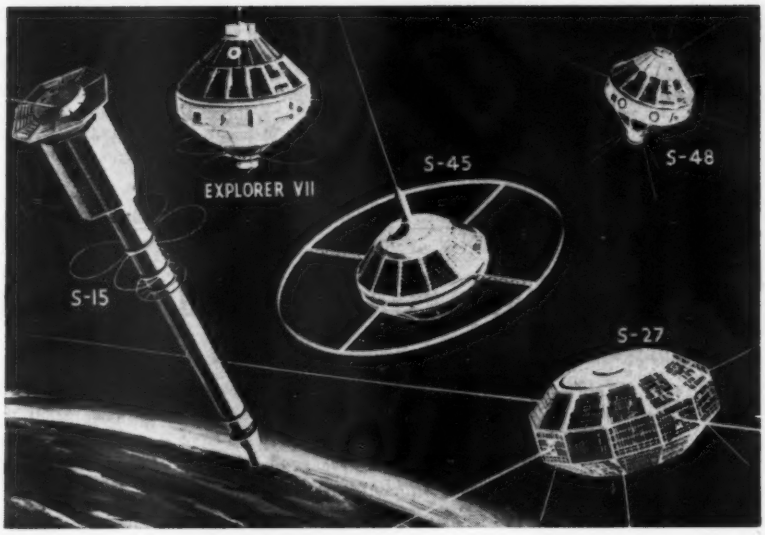
1 *Ultraviolet spectrum of the sun, taken from a high-altitude rocket*
The arrow indicates the Lyman alpha line of atomic hydrogen

Perhaps the most beautiful result of researches of this kind is one in which a crude photograph of the sun was taken with X-rays. Since X-rays cannot be focused by



2 *The sun photographed in Lyman alpha ultraviolet light (left) and white light (right)*
The ultraviolet is intense in the regions of sunspots

lenses, the principle of the pinhole camera was used. The rocket was stabilized to point the camera towards the sun, but it was not possible to stop it rotating about its axis. The result was that, with the exposure times involved, the photograph was somewhat blurred by rotation round its centre. It is shown in Fig. 3, and, again, the way in which the sources of X-radiation are distributed over the disc is of interest to solar and ionospheric physicists.



4 *Some typical experimental satellites*

Phenomena at great altitudes

Although, for some purposes, it may be said that apparatus at a height of 120km is outside the atmosphere, what is above is nevertheless measurable. It can be studied by observing the motions of artificial satellites, which are slightly impeded by collision with the few remaining air molecules. From the corresponding changes in the orbit, deductions can be made about the density of the air. In this way it has been shown that above 200km there is an important difference in density between day and night. The upper atmosphere is apparently denser and presumably hotter by day than by night, and the difference is greater at the greater heights. During a magnetic or ionospheric storm, the density increases even further, and again the increase is greater at the greater heights.

Of the many investigations that have been made with apparatus sent aloft in a satellite, those that established the existence of the Van Allen belts are probably the most important. The apparatus consisted of electronic counters arranged to determine the number of impacts made by different kinds of particle and to transmit the result to the ground by telemetry. It was shown that there are two belts of energetic particles 'trapped' in the magnetic field of the Earth. The outer belt is about four Earth radii from the centre of the Earth above the Equator and consists of electrons with an energy of about 100keV; the inner one is distant about $1\frac{1}{2}$ Earth radii and consists of electrons and protons with energies of about 50keV and 100MeV respectiveiy. The constitution of the outer belt changes during magnetic and ionospheric storms.

3 *The sun photographed in solar X-rays by a pinhole-camera technique*

The image is blurred by rotation about the centre

Anglo-American satellites

At heights of more than about 300km above the Earth, the air resistance is so small that satellites need not be designed for small atmospheric drag. They therefore take unusual shapes, of the kinds illustrated in Fig. 4. The most noticeable features are the numerous and often complicated aerial systems and the panels of solar cells that occupy most of the surface. Each square centimetre of these cells supplies about 0·01W, and a large surface area is required if the equipment consumes much power. Of course, the cells work only when in sunlight, and batteries have to be provided to keep the apparatus working when the satellite is on the dark side of the Earth.

The United States has offered a series of satellites to carry the experiments of workers in the United Kingdom. It is intended to launch the first of this series during 1962, and it will carry experiments on behalf of:

1. University College London, to measure electronic and ionic concentrations and temperatures in the upper ionosphere and the intensity of solar ultraviolet and X-radiation
2. Birmingham University, to measure electron concentrations by a different method
3. Imperial College, London, to measure cosmic rays.

Other experiments by different workers are planned for the second and third of these satellites. Workers in the United Kingdom have also made much use of Skylark rockets fired from the rocket range at Woomera in Australia. Increasingly, more research groups in Britain will be gaining experience with rockets and satellites and making worthwhile experiments in 'space science'.

THE JOURNAL DIGEST | PAPERS READ

The articles in this regular monthly feature are based on current papers read at Institution meetings. They are written by the authors of the papers, who have been asked to make the articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics discussed. While the articles bring out the main points and conclusions of the papers, their contents are not necessarily confined to the subject-matter of the original papers

ELECTRICITY SUPPLY IN INDIA AND ITS FUTURE

A short review of the Supply Section Annual Lecture (3703) with the above title by M. Datta, M.Sc.Tech., Ph.D., which was delivered on the 10th May 1961 at Savoy Place. (A report of this meeting appeared in the July 1961 Journal, p. 474.) The lecture is published this month in Part A of the Proceedings. The author is with the West Bengal State Electricity Board.

INDIA today, having an area of 1·27 million square miles, is a secular country with a population exceeding 430 millions, 70% of whom are engaged in a medieval system of agriculture. The majority of the population live in nearly half a million villages, with inhabitants ranging from about 250 to 10000, and so far only the large towns and villages have been provided with electricity. The transport of heavy equipment is one of the difficulties of an underdeveloped country, as can be seen from Fig. 1.

With an annual average energy consumption of 1200×10^9 kWh/year, of which $15{\cdot}1 \times 10^9$ kWh/year is electrical, the *per capita* annual consumption in India is 40 kWh, compared with a world average of 600 kWh and outstanding figures such as 4400 kWh for the United States.

Plan targets

Generation and distribution of electricity are the responsibility of the State Electricity Boards, whose programmes are co-ordinated by the Ministry of Irrigation and Power through the Central Water and Power Commission.

The installed capacity at the beginning of the First-Plan period was 2300 MW, to which an addition of 1100 MW was made. During the Second Five-Year Plan (1956–61), with an addition of 2400 MW of installed generating capacity, the total installed generating capacity became 5800 MW, as against the target of 6900 MW. In the two Plan periods now completed, the number of towns and villages electrified has increased from 3667 in 1950–51 to 19000 in 1960–61.

India has recently moved from the Second to the Third quinquennial period of planned development. In the Third-Plan period, it is expected to increase the generating capacity to 11800 MW by the end of 1966.

The target provides for nuclear power generation to the extent of 300 MW, and it is expected that a further 15000 towns and villages will be electrified in this Plan period.

Sources of energy

The rivers of India can be divided into two broad categories: those exclusively rain-fed and those snow-fed as well as rain-fed. Because of seasonal rainfall (June–September), the former rivers are characterized by heavy discharge during the monsoon months, but the flow dwindles to a mere trickle during the summer. Even in the latter group, originating in the Himalayas, the perennial snow-feed reduces the wide flow variation but slightly.

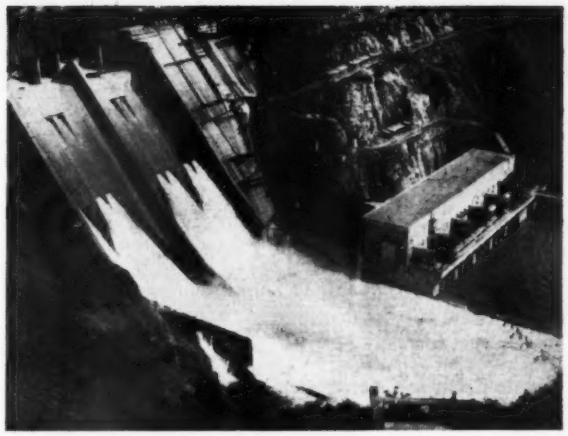
Hydro-power stations in India are therefore dependent on regulation of the fluctuating river flows by construction of dams and reservoirs at favourable sites, subject to the overriding requirements of irrigation and flood control. The country's water-power potential is about 40 million kW at 60% load factor—an energy potential of 210 million MWh annually or the equivalent of consuming 150 million tons of coal per annum. One of the greatest potentials is in the

1 *A 21½ ton transformer being drawn on a bullock cart*
A distance of 7½ miles was covered in 3½ hours

U-bend of the Brahmaputra, just before it enters India from Tibet, which might be exploited for the mutual benefit of both countries. Over a distance of 125 miles the river falls 8000ft and has a minimum unregulated flow of 30000cusec. At present only about 6% of India's water-power potential is utilized for the production of energy. Fig. 2 shows the hydro and coal resources of India.

The known resources of coal in India, assessed at 120000 million tons, are localized in the four eastern States, West Bengal, Bihar, Madhya Pradesh and Andhra Pradesh. Most of the resources are of inferior quality. The limited resources of higher-grade coking and non-coking coals are conserved for metallurgical industries. Oil and natural-gas resources are small.

India has to consider nuclear power generation in places far remote from coal reserves and water-power sites. It has been estimated that the total resources of thorium in India amount to over 500000 tons in a readily extractable form, while the known resources of uranium are less than a tenth of this tonnage. Nuclear power generation will therefore be based on thorium, developed in three stages. The first stage will utilize reactors fuelled by natural uranium producing plutonium as a by-product. In the second stage, the intention is to utilize plutonium with thorium in fast breeder reactors to produce uranium 233, while in the third stage reactors operating with thorium and plutonium as fuel are envisaged.



3 *The Bhakra dam and left-bank powerhouse*

One of the factors affecting the choice of mode of generation is the foreign-exchange component of the currency required. For a coal-fired station, this is two to three times higher than that for a hydro station, while for nuclear power stations it is even more. Thus it is likely that hydro resources, backed by coal-fired power stations, will play an important part in the power development of India for many years to come.

2 *Hydro and coal resources of India, with location of power stations*

Power generation

Important features are the concentration of generation in regional stations and their interconnection to form regional Grids, leading to the adoption of high-pressure, high-temperature, high-rating turbo-alternator and boiler units. The size of the units now being installed ranges between 30 and 125 MW.

The new important thermal stations are all in the Eastern Zone, comprising West Bengal, Bihar and Orissa, with vast industrial potentialities. The new Chandrapura station will operate with steam at 1800 lb/in.^{2} (gauge) and 1000° F. The new Bandel thermal station near Calcutta, with four generating units of 75 MW each, will have steam conditions of 1450 lb/in.^{2} (gauge) and 1000° F, with single-stage reheat at 1000° F. The station is expected to burn coal-washery middlings and rejects with an ash content of about 40%.

The large hydroelectric schemes at present being completed will have units of higher rating, namely Bhakra with 10 sets of 90 MW, Koyna with 5 sets of 60 MW, Rihand with 5 sets of 60 MW, and the Sharavathi Valley Project with 10 sets of 90 MW. The Bhakra dam and left-bank powerhouse are shown in Fig. 3.

Papers read (continued)

Users of electricity

Electricity has become the main source of power and has resulted in the formation of several new industries, e.g. electrometallurgy, electrochemistry and the production of aluminium, iron and steel, manganese, calcium carbide and nitrogenous fertilizers. Electrification of the railways on a 25kV a.c. 50c/s system has been taken up specially for dealing with the heavy traffic of steel plants.

Of the energy generated in 1960–61 by public utilities, 69% was used for industry, only 17% for commercial and domestic purposes and 10% for irrigation and waterworks. The traction requirement was only 3%.

Transmission and distribution

The transmission and distribution system has to operate in extreme climatic conditions. In consequence, the rating of equipment has to be reduced. The temperature and wind-load conditions vary widely, and the worst wind load does not occur during the minimum-ambient-temperature condition.

Lightning disturbance constitutes the most frequent cause of supply interruption on overhead power lines. At and above 66kV, the protection against lightning is obtained by provision of overhead earth wires on the transmission lines and by proper insulation co-ordination.

For the distribution system, the use of unearthed and unbonded lines on wood poles provides the best performance in lightning conditions and avoids the risk of shock.

Conclusion

Technology holds the key to economic progress in India and will play a crucial role even in shaping her politics. Human skill and natural resources await the magic tool of electricity to give wings to India's economy. 621.311.1(54)

ANALOGUE-COMPUTER SIMULATION OF NUCLEAR REACTORS

A short account of a Measurement and Control Section paper (3704) 'The use of analogue computers in predicting the space–time behaviour of nuclear reactors' by R. W. Hockney, M.A., and T. O. Jeffries, M.A., D.Phil., A.Inst.P. The paper was published individually in October 1961 and will be republished in Part A of the Proceedings. It was read before a Section meeting on the 24th October 1961 at Savoy Place *(see p. 780).* *The authors are in the Atomic Power Division, English Electric Co. Ltd.*

NUCLEAR reactors currently being built in the United Kingdom consist of a cylindrical graphite core some 25ft high and 50ft in diameter, in which there are about 4000 4in.-diameter channels. Inside the channels are stacked fuel elements consisting of uranium rods, about 1in. in diameter, enclosed by fuel cans that have a finned surface to improve heat transfer. Carbon dioxide coolant gas is blown up the channels to remove the nuclear heat and is subsequently passed through heat exchangers, where the heat is used to produce steam. The steam produced is used to generate electricity in the conventional way. The reactor is controlled by neutron-absorbing rods that penetrate the reactor core from the top and may be moved to change the reactivity of the reactor.

Behaviour of a reactor

The temperature and neutron density in a nuclear reactor are determined by the reactivity of the reactor core, and, because the reactivity itself depends on the temperature of the uranium and graphite, a reactor is a feedback system. The system is non-linear, partly by virtue of the non-linearity of the neutron-density equation itself and partly because of speed and position limitations in the automatic-control system.

Because of these complications, the behaviour of a reactor and of its control system is most conveniently simulated on an analogue computer.

The neutron-density equation contains both space and time derivatives. Analogue-computer equipment is ideally suited for integration with respect to time but has no special features making it suitable for representing space derivatives. Various approximate methods must therefore be used.

Model representations

A point model may be constructed on the assumption that the macroscopic spatial shape of all variables remains the same during a transient. The model represents the state of a reactor by a number of averaged parameters of the reactor. These might be the average fuel temperature, average graphite temperature, average coolant temperature and average neutron density of the reactor. This model is used to study the behaviour of the automatic-control system in controlling the total power of the reactor.

During the start-up of a reactor, control rods are withdrawn and the axial shape of the temperature and neutron density undergoes radical changes. Consequently, the assumption of constant spatial shape, made for the point model, is inadequate. To allow for axial variation, a four-zone simulation is made by dividing the reactor into four zones axially and by simulating equations, for average properties, within each

zone. The simulator may be considered as four point-model representations linked together by neutron diffusion and by the coolant-gas flow.

Forms of instability

The large civil reactors at present being built in Britain, if uncontrolled, are unstable with respect to total power with a period of divergence of about 10min; and an automatic-control system may be designed to control total power, using the point model already described.

Another possible form of instability results in an increase in neutron density in some parts of the reactor and a decrease in others, with little change in total reactor power. To control this spatial instability, it is necessary to divide the reactor into sectors, usually 9–12 in number, and to have a separate control system in each sector to keep the temperatures constant. These control systems are interconnected by neutron diffusion.

Radial/azimuthal harmonic simulation

A simulation of such a system requires a radial/azimuthal representation, and it is found convenient to expand the space dependence of all variables in a series of spatial harmonics (similar to a Fourier-series expansion). The amplitudes of the different harmonics depend on time only, and these are represented on the analogue. The radial/azimuthal simulation uses an expansion of 17 harmonics and represents 12 control systems.

681.142:621.039

ELECTRICAL PHENOMENA AT VERY LOW TEMPERATURES

A short article based on a Graduate and Student Section paper with the above title by R. E. Hayes, M.Sc., Ph.D., Graduate. The paper was read before a joint meeting of the Southern Centre and the Southern Graduate and Student Section at Romsey on the 23rd March 1960, and before the North-Eastern Graduate and Student Section at Newcastle upon Tyne on the 21st October 1960. The paper was awarded a premium by the Council. The author is with the Plessey Co. Ltd.

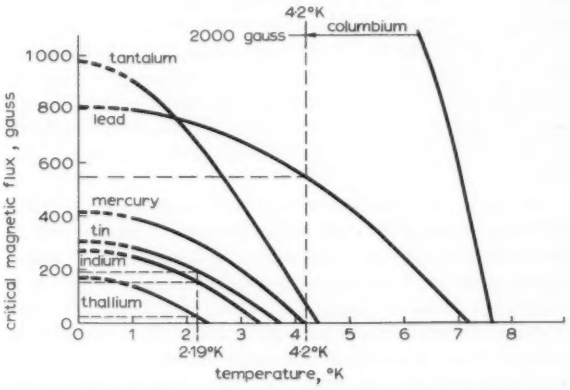
BEFORE 1956, experimental work at very low temperatures was performed on a small scale and almost entirely at universities. However, in April 1956 a paper was published by the late Dudley A. Buck that aroused the interest of computer engineers and has resulted in a great expansion of all types of work conducted at very low temperatures. An appreciable portion of this work has been carried out by industrial concerns to produce component parts for high-speed digital computers.

Below about 10°K, the only available refrigerant is helium gas, and hence any work below this temperature is intimately connected with the technology of the liquefaction of this gas and the storage of the liquid. Temperatures between 10° and 4·2°K (the temperature at which helium liquefies) are not readily achieved, but those down to 1·5°K are easily obtained by reducing the vapour pressure over the liquid helium by means of a vacuum pump.

Liquid helium and superconductivity

Helium was first liquefied in July 1908 by Kamerlingh Onnes at Leiden, producing a clear colourless liquid with a normal boiling point of 4·2°K. In 1947 S. C. Collins in the United States designed and produced a liquefier capable of commercial exploitation and yielding appreciable quantities of liquid helium. In Great Britain, it has been found feasible to use one central liquefier (initially a Collins machine located at the National Physical Laboratory at Teddington) and to sell and transport the liquid to other laboratories.

One of the first experiments performed using liquid helium was an investigation into electrical conductivity. Experiments carried out on mercury in 1911 showed the surprising result that, while the resistance of a sample gradually decreased with falling temperature, at 4·16°K it suddenly dropped from a finite value to an immeasurably small one. Since that time

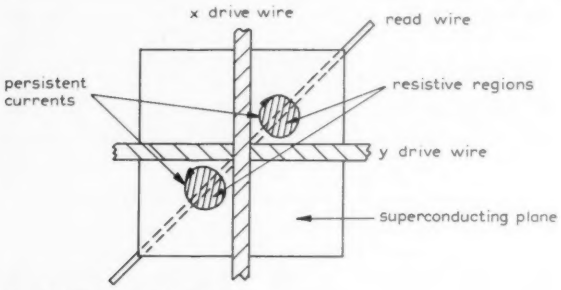


1 *Disappearance of superconductivity with flux density and temperature*

many metals have been found to exhibit this superconductivity. The temperature at which it happens is the transition point (T_c). Although superconductivity was discovered 50 years ago, no really satisfactory physical explanation exists for it. However, the evidence tends to suggest that the superconducting resistance is truly zero.

In trying to exploit superconductivity it was soon found that it could be destroyed either by exceeding a certain critical current in a conductor or by an external magnetic field. In 1917 Silsbee suggested that these two effects were really one. He concluded that superconductivity disappeared

abruptly when the magnetic flux density at the surface of a conductor reached a certain critical value that depended on the temperature. A graph of this dependence is shown in Fig. 1 for metals with transition points down to 2°K. It is on



2 *Continuous-sheet memory*

this phenomenon that most devices utilizing superconductivity depend.

Applications of superconductivity

The first real use of superconductivity was by Templeton, who made a superconducting reversing switch to discriminate against the thermal e.m.f.s generated in the leads from a cryostat. Templeton also devised a superconductive chopper to increase the range of his measurements by keeping his detector at liquid-helium temperature and thus decreasing the thermally generated noise. A modulated magnetic field causes a section of fine tantalum wire to act as a chopper by switching between zero and about 0·1Ω across the primary of a transformer.

The same principle of switching with an external magnetic field was exploited by Buck in his invention of the cryotron. He demonstrated that it was possible for a device of this nature to belong to the active class of component, such as a valve or transistor. The cryotron was constructed from a 0·009 in.-diameter tantalum wire, called the gate, closely wrapped with a solenoid of insulated columbium wire 0·003 in. in diameter, called the control. Both metals are superconducting at 4·2°K, but tantalum requires a flux density of only 60 gauss to make it resistive, while columbium requires a flux density in excess of 2000 gauss. Thus it can be arranged that the columbium is always superconducting, whatever the state of the tantalum wire.

The cryotron is switched by making the gate wire resistive with the magnetic field due to the control winding. The disadvantage of the simple cryotron is its large L/R time-constant. If the gate wire is reduced to a thin evaporated film, its normal-state resistance is greatly increased. If at the same time the control winding is reduced to a single crossing of the gate film, its inductance is appreciably reduced. Along these lines was developed the crossed-film cryotron, fabricated by multiple evaporation of suitable metals and insulators in a vacuum evaporator. Much effort is now being concentrated on producing large arrays of interconnected crossed-film cryotrons to perform logical operations in digital circuits.

Investigations have been made on the use of a circulating current as a storage element. Such a current can flow in two possible directions, which can represent the binary 0 and 1 and hence form a memory. The first realizable element using this principle was devised by Crowe. It consists of a hole in a superconducting sheet bridged by a narrow strip, and the operation of the element or cell depends on the direction of flow of a persistent current flowing in the bridge. The disadvantages of a Crowe-cell memory are that very close tolerances are demanded on the dimensions of the bridge and that its shape makes wiring for co-ordinate selection memories difficult.

A new form of storage cell that overcomes these problems is the continuous-sheet memory shown in Fig. 2. The information is stored as a persistent current at the boundary between a superconducting and a resistive region, and in the equilibrium position the trapped flux is sufficient to keep the enclosed portion in the resistive state. The continuous-sheet memory has distinct possibilities as a high-speed computer store of the future.

A superconducting gyro

A different application of superconductivity is found in the gyro invented by Buckhold in the United States. In this application, the repulsive force existing between a persistent current and the field producing it is used to support a superconducting rotor *in vacuo*, giving a friction-free bearing with a powerful self-centring action. It is also claimed that the very low operating temperature eliminates creep in the metals of the gyro and the errors caused by this.

Semiconductor applications

At very low temperatures, with small applied voltages, germanium has a very high resistivity. Above a certain critical applied field, a reversible breakdown occurs that is similar in many respects to avalanche breakdown in a gas. If compensated germanium is used, the sustaining field after breakdown is lower than that required to initiate it, producing a 'negative-resistance' characteristic. Work is proceeding on a cryosar using this effect. One possible application of this device is as a selection switch for use with superconducting memory-elements.

Latest developments

It has recently been found that, if a sandwich is made of two different superconducting metals separated by a very thin insulator, such as lead, aluminium oxide and aluminium (T_c for aluminium is 1·18°K), a device with a 'negative-resistance' characteristic, similar to that of the tunnel diode, is obtained. Research is now under way to see whether the phenomenon occurs at higher temperatures with different superconductors. If so, a device with many exciting potentialities will be added to the growing list of those that make use of electrical phenomena at very low temperatures.

537.312.62: 681.142: 621.374.32

In this monthly section are summaries of papers published in the *Proceedings* of The Institution that have not been read at Institution meetings. They are included primarily for reference. Reprints, price 2s., become available about two months after publication

Quadrature-axis synchronous reactance

A summary of a Supply Section paper (3750) 'An experimental effective value of the quadrature-axis synchronous reactance of a synchronous machine' by R. E. Steven, B.Sc., Ph.D., Associate Member. The paper is published this month in Part A of the Proceedings. The author is in the Electrical Engineering Department, University of Southampton.

THE author carried out experimental tests on two dissimilar salient-pole synchronous machines. Each machine was run as a synchronous motor on constant-voltage busbars. An examination of the results confirmed the inaccuracy that occurs in the predicted value of the load angle δ when the quadrature-axis reactance is assumed constant.

An original analysis of the experimental results is given whereby it is shown that the effective value of the quadrature-axis reactance can be expressed in the form:

$$X_{qeq} = k_1 + \frac{k_q}{I^{(1-n)}}$$

The factors involved are defined in the following way:

$k_1 = (X_d/X_q)X_1$, i.e. a function of direct-axis leakage reactance.

X_d and X_q are the conventional unsaturated values of the direct-axis and quadrature-axis reactances, obtained by, say, the slip test. X_1 is taken as equal to the Potier reactance.

n is an index determined from the open-circuit characteristic of the machine, which, it is proposed, may be interpreted in a form $V = k_f I_f^n$ over a significant part of the curve. I is the armature phase current.

The factor k_q is examined as a function that determines the effect of armature reaction, and it is shown that, in general for a synchronous machine, it may be expressed in the form:

$$k_q = \frac{X_d}{K_1}\left(1 - \frac{X_1}{X_q}\right)[1 + \tan(\delta + \phi)]$$

where K_1 is a saturation factor, ϕ is the phase angle of the armature current and δ is the load angle in electrical degrees.

It is further shown that the author's expression for the effective value of X_q permits accurate prediction of load angle over a range of load conditions for several machines. A derived expression for $\tan\delta$ is given that enables the prediction to be carried out by direct substitution. 621.313.321.011.2

Starting single-phase induction motors

A summary of a Utilization Section paper (3747) 'The starting of single-phase induction motors having asymmetrical stator windings not in quadrature' by C. S. Jha, B.Sc., Ph.D., Graduate. The paper will be published in Part A of the Proceedings. The author was formerly in the Department of Electrical Engineering, University of Bristol, and is now in the Department of Electrical Engineering, University of Roorkee (U.P.), India.

GENERALIZED rotating-field concepts, developed in an earlier paper, are used to analyse the behaviour of a single-phase induction motor having asymmetrical stator windings not in quadrature. The analysis includes the effects of the air-gap harmonic fields and is applicable for all values of the turns ratio k and the displacement angle θ. It is shown that the generalized equations of performance reduce to those obtainable by other methods for the few special combinations of k and θ where the latter could be accurately applied.

The starting performance of the motor is expressed in terms of dimensionless parameters, and the effect of θ on the starting torque is discussed in some detail. It is shown that, although more starting torque is obtained by making θ greater than 90°, the magnitude of the increase depends on the rotor resistance and the effects of the harmonic fields. Tests on standard machines show good agreement with theoretically predicted performance. 621.313.333.016.1

The date in italics is that of the Journal review, special article or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (DECEMBER 1961)

A. N. ARMAN, PH.D., F. J. MIRANDA, DR.-ING., *and* G. R. BISHOP. PAPER 3513S, MARCH 1961 **Progress in oil-filled cables and their accessories** *October 1961*

P. GAZZANA-PRIAROGGIA, DR.-ING., G. L. PALANDRI, DR.-ING., *and* U. A. PELAGATTI, DR.CHEM. PAPER 3348S, NOVEMBER 1960 **The influence of ageing on the characteristics of oil-filled cable dielectric** *October 1961*

In the Proceedings (continued)

Communicated discussion on **A basis for short-circuit ratings for paper-insulated cables up to 11kV**

REPORT 3705 Discussion on **Magnetohydrodynamic generation of electricity**

Communicated discussion on **Open-circuit noise in synchronous machines**

M. DATTA, M.SC.TECH., PH.D. PAPER 3703S **Electricity supply in India and its future** *December 1961*

Discussion on **The logical design of electrical networks using linear programming methods** before the North-Western Supply Group

Discussion on **Development of high-voltage air-break circuit-breakers with insulated-steel-plate arc chutes** before the South Midland Centre

W. CASSON *and* H. J. SHEPPARD, B.SC. PAPER 3528S, MARCH 1961 **Technical and economic aspects of the supply of reactive power in England and Wales** *June 1961*

D. S. ASHWORTH, B.A., *and* P. HAMMOND, M.A. PAPER 3489S, MARCH 1961 **The calculation of the magnetic field of rotating machines—Part 2** *June 1961*

P. J. LAWRENSON, M.SC. PAPER 3490S, MARCH 1961 **The magnetic field of the end-windings of turbogenerators** *June 1961*

Discussion on **The impulse strength of fully-impregnated-paper dielectrics as used in high-voltage cables** before the North-Western Centre

J. HINDMARSH, B.SC.(ENG.), *and* N. K. GHAI, B.SC.(ENG.), M.SC.TECH. **Objective methods of assessing commutation performance** (communication)

Discussion on **The characteristics and protection of semiconductor rectifiers** before the West Wales Sub-Centre

R. E. STEVEN, B.SC., PH.D. PAPER 3750S **An experimental effective value of the quadrature-axis synchronous reactance of a synchronous machine** *December 1961*

J. C. JONES. **Recent developments in magnetic work-holding devices for machine tools** (communication)

Discussion on **A survey of street lighting and its future** before the North-Western Utilization Group, the North Lancashire Sub-Centre and the Northern Ireland Centre

Discussion on **Submersible pumping plant** before a joint meeting of the North-Western Centre and the Mersey and North Wales Centre and before the South-East Scotland Sub-Centre

Communicated discussion on **Measured and electrical-model characteristics of buildings heated by floor thermal storage**

Discussion on **Some considerations in the application of power rectifiers and convertors** before the South Midland Supply and Utilization Group and the North Staffordshire Sub-Centre

Discussion on **The shielding of overhead lines against lightning** before the North Staffordshire Sub-Centre and the Western Supply Group

Discussion on **The application of irradiation in industry** before the Northern Ireland Centre and the South Midland Supply and Utilization Group

Discussion on **The application of low-pressure resins to some high-voltage switchgear design** before the South Midland Supply and Utilization Group

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (NOVEMBER 1961)

See the Journal for November 1961, p. 670

PART C. MONOGRAPHS (SEPTEMBER 1961)

See the Journal for September 1961, p. 567

THE JOURNAL DIGEST | MONOGRAPHS

Monographs are first published individually, price 2s., and are republished later in Part C of the Proceedings of The Institution. As soon as the separate monographs are available, summaries are given in this feature.

Applications quoting the serial number of the monographs as well as the author's name, and accompanied by a remittance, should be addressed to the Secretary of The Institution.

For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

A locus diagram to determine the complete starting performance of a 3-phase induction motor connected to a single-phase supply

Monograph 486U

A. R. DANIELS, M.SC., *and* B. R. PELLY

A GRAPHICAL solution, which gives the sequence voltages, the starting-torque ratio, the line current, the voltage across the capacitor and the corresponding values of a dimensionless admittance ratio for a 3-phase induction motor at standstill and connected to a single-phase voltage, is derived. Several optimum conditions, in particular an exact admittance ratio for minimum unbalance, are obtained from the locus diagram. In all cases, it is shown that the admittance ratio obtained is independent of the applied voltage, and the locus diagram is therefore applicable to machines of any rating.

An analytical method taking account of saturation and hysteresis for evaluating the iron loss in solid-iron cores subjected to an alternating field

Monograph 485U

PROF. N. KESAVAMURTHY, M.A., B.E., M.SC.TECH., *and* P. K. RAJAGOPALAN, B.E., M.S., PH.D.

AN attempt is made to obtain an analytical solution for the field distribution inside solid magnetic cores subjected to an alternating magnetic field when the range of operation of the magnetizing force is limited to the first portion (up to the knee) of the B/H curve that can be approximated to the form $B = \mu(H - \epsilon H^3)$, ϵ being small. As a first stage, an analytical method is developed for the solution of the partial differential equation of the form:

$$\frac{\partial^2 H}{\partial x^2} = \frac{\mu}{\rho}\frac{\partial}{\partial t}(H - \epsilon H^3)$$

H being a function of x and t.

Based on this method, expressions for the field distribution, eddy-current loss and over-all power factor are deduced. Furthermore, the above analysis is modified to take account of the presence of hysteresis. It is claimed that the method gives a clear picture of the saturation phenomenon and offers an explanation for the increases in loss and power factor that accompany saturation. The analysis is applied to the specific case of a mild-steel toroid and verified against the test results.

The design of a wide-band transistor telephone repeater and its distortion performance

Monograph 484E

B. S. HELLIWELL, M.A., E. E. ALDRIDGE, B.SC.(ENG.), *and* J. A. BARRETT, B.SC.

THE design of a two-stage transistor amplifier having over-all current feedback is considered. Allowance is made for variation of the transistor parameters, their noise figures and inherent non-linearities. The stability of the feedback loop of the amplifier is investigated and its operation as a wide-band (60–1300 kc/s) telephone line repeater outlined.

Finally, a modified two-stage amplifier, utilizing a cascode output stage to improve its harmonic distortion, is described, together with a method of estimating the distortion produced by such amplifiers.

A method of determination of all the minimal forms of Boolean functions

Monograph 487E

A. MUKHOPADHYAY, M.SC.(TECH.)

A METHOD of minimization of Boolean functions is described. Though directly concerned with the evaluation of the minimal sum of products, it can be easily extended to obtain the minimal product of sums. It has been shown that, after the selection of the essential prime implicants, there exists a 'row-merger' step or a 'row-merger' and 'row-cancellation' step that reveals many alternative covers.

The method of obtaining the solution for the cyclic prime implicant matrix has been systematized by introducing the 'irredundant S^{at}-set' and the 'perturbation set' of the prime implicants. The method yields all the minimal sums, however complex the problem may be.

Tensor analysis of a synchronous two-machine system

Monograph 488S

J. W. LYNN, M.SC., PH.D., *and* M. H. WALSHAW, B.SC.(ENG.), PH.D.

IN the analysis of electrical machines, certain physical concepts are common to all machines, whatever the axes of reference, e.g. resistance voltage-drop. These invariant quantities can be expressed mathematically as tensors. The authors investigate the form of the invariant equations of a two-machine system. One basic equation in its general transient form, and the corresponding hunting equation, are used for the two individual machines, and it is shown that the same two equations apply to the connected system.

The tensor equations are expanded to give the full matrix equations of the system. The application of the latter has already been published by the authors.

Flow graphs, signal-flow-graphs, and graph determinants

Monograph 489E

R. F. HOSKINS, M.SC.

THE flow graph, introduced by C. L. Coates, is a structure, allied to the signal-flow-graph, that allows the solution of a system of linear equations to be found in a way that avoids certain redundancies. The author shows how the essential advantages of Coates's theory can be incorporated into signal-flow-graph analysis. Where network theory is concerned, it seems preferable to retain the signal-flow-graph form, and the reasons for this are discussed. In addition, the precise relations between graph determinants and the determinants of ordinary algebraic theory are examined. The aut or concludes with a comparison of the algebra of flow-graph and of signal-flow-graph transformations.

A theory of the operation of cylindrical induction motors with squirrel-cage rotors

Monograph 490U

L. S. PIGGOTT

THE electric- and magnetic-field vectors in the air-gap of an induction machine are derived from a scalar potential that satisfies Laplace's equation; the application of boundary conditions at the stator and rotor surfaces then leads to a complete knowledge of the air-gap field and the rotor current in terms of the stator current. All the electric and magnetic quantities can be expanded in a series of travelling harmonics, each of which produces its own component of torque and rotor I^2R loss. The pulsating component of torque is the only derived quantity that depends on interaction between the harmonics.

The general theory is applied to the polyphase machine, the single-phase machine and the 2-phase servomotor; in each case, the result conforms with accepted theory

The theory could well be applied to machines with unusual stator windings.

Measurement of small, fast variations in complex permittivity at ultra-high frequencies

Monograph 491E

DR. E. FATUZZO

USING a slotted line, a method has been developed to measure small and rapid variations, $\Delta\epsilon'$ and $\Delta\epsilon''$, in the real and imaginary parts, ϵ' and ϵ'', of the relative permittivity of a dielectric at frequencies in the range 250–2000 Mc/s. Some measurements made by this method on ferroelectrics during switching gave consistent results.

The calculation of the electric field for an infinite dielectric plate between two spherical electrodes

Monograph 492M

K. C. KAO, B.SC., M.SC., PH.D., *and* T. HARKER, B.SC.

BY considering the equipotential surfaces round two equal and opposite point charges, the electric field for an infinite dielectric plate between two spherical electrodes has been calculated. The solution is given as an infinite series in terms of applied voltage, radius of the electrodes, thickness of the dielectric plate, and permittivities of the plate and the medium. Curves have been derived to show the significance of the dependence of the voltage gradient in the field on the ratio of the plate thickness to the electrode diameter and the ratio of the permittivity of the plate to that of the medium. The edge effect in the electric breakdown of solid dielectrics may be attributed to the discharge in the medium, which occurs when the voltage gradient on the electrode surface reaches a value favourable to its breakdown condition.

Limits of accuracy in resistance measurement

Monograph 493M

C. H. MILLER, B.E., D.PHIL.

THE resolution that can be achieved in resistance measurement is shown to be limited by the amplitude of thermal noise relative to the input power of the resistance. The errors of measurement owing to resolution and power loading are analysed, and the minimum value of their sum is found to be proportional to the cube root of the circuit and detector noise factors, the detector bandwidth and the load-correction error. The noise factors of some common circuit arrangements are evaluated, and the other errors of measurement, in addition to resolution and power-loading errors, are discussed. The total error is shown to have a limiting value near 1 part in 10^8 for existing high-quality standard resistors, and this is illustrated by a practical example.

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned, except where otherwise stated in a footnote

BRITISH BROADCASTING CORPORATION

Monograph no. 39 **Twenty-five years of B.B.C. television** by Sir Harold Bishop. London, 1961. 5s.

THE main engineering developments during the 25 years since the B.B.C.'s television service started are discussed. Techniques originated by the Corporation or used in a specially noteworthy manner in their service are paid particular attention. The B.B.C.'s contributions to probable future developments, including colour television and a change of line standards, are briefly reviewed.

B.B.C. television. A British engineering achievement. 2nd edition (revised). London, 1961. 3s. 6d.

A BRIEF description of how television works is given. The Television Centre, news studios and regional centres are described. Recording programmes, equipment, outside broadcasts, colour television and many other points are discussed.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

Report O/T26 **Current-carrying capacity of bare aluminium, aluminium alloy and steel-cored aluminium conductors for overhead power transmission. Third report** by H. Goldenberg. 5s., postage 6d.

CURRENT ratings are given for aluminium, aluminium alloy and steel-cored aluminium conductors for overhead-power-transmission purposes. For each conductor cross-sectional area, the ratings are listed for conductor temperature rises above ambient, for black or bright conductors, for conductors shielded from or exposed to the sun, for still air and for air with a velocity of 1 m.p.h. The direct calculation of the majority of current ratings may be carried out by using the digital-computer programme given.

Report V/T133 **An audio-frequency buffer amplifier with isolated output** by P. G. Kendall and A. B. Sylvester. 7s. 6d., postage 6d.

AN amplifier, developed for use in the generator units of the E.R.A. network analyser, is described. The generator units were required to provide an undistorted output of very low impedance, isolated from earth and capable of supplying a wide range of loads.

BRITISH STANDARDS INSTITUTION

Annual report 1960–61. 7s. 6d.

THE period from the 1st April 1960 to 31st March 1961 is covered. There are four sections—'General report', 'Divisional reports', 'International activities' and 'Councils, committees and officers of the Institution'. A standards committee for the data-processing industry was set up during the year.

B.S. 156: Part 1: 1961 **Enamelled copper conductors** (oleo-resinous enamel). Part 1—Round wire. 7s. 6d.

THE requirements and dimensions for round copper wire covered with oleo-resinous enamel are given.

B.S. 162: 1961 **Electrical power switchgear and associated apparatus.** 17s. 6d.

REQUIREMENTS for switchgear in excess of 100 V d.c. and a.c. (and frequencies up to 100 c/s in the latter case), such as is employed with generating, transmitting, transforming and converting plant and large motors, are co-ordinated in this publication. There are nine illustrations, and Figs. 5–9 are reproduced on a larger scale as B.S. 162C: 1961, price 30s.

B.S. 158: 1961 **Marking and arrangement of switchgear busbars, main connections and small wiring.** 5s.

THE markings and arrangements are related to power-switchgear assemblies as given in B.S. 162 'Electrical power switchgear and associated apparatus'.

B.S. 196: 1961 **Protected-type non-reversible plugs, socket-outlets, cable-couplers and appliance-couplers with earthing contacts** for single phase a.c. circuits up to 250 volts. 15s.

DIMENSIONS necessary to ensure interchangeability and non-interchangeability, when required, of complete plugs in complete sockets of different make are given. Two types are covered, namely two-pole, and two-pole and pilot contact.

B.S. 216: 1961 **Vulcanized fibre sheet for electrical purposes.** 6s.

VULCANIZED-fibre sheets for electrical purposes, from $\frac{1}{16}$ to 1 in. in thickness, are specified. Included in the appendixes is a method for determining the electric strength.

B.S. 456: 1961 **Dimensions of track circuit insulation.** 12s. 6d.

INSULATIONS for rail joints for certain sections of bullhead- and flat-bottom rails are covered. Sole-plate, stretcher-bar and rod-joint insulations are also given.

B.S. 601: Part 2: 1961 **Steel sheets for magnetic circuits of power electrical apparatus.** Part 2—Oriented steel. 5s.

STEEL strip and sheets, primarily for machines and transformers operating at power frequencies, are covered. Material coated on both sides with a suitable insulation capable of withstanding stress-relief annealing in conditions approved by the manufacturer is dealt with.

B.S. 634: 1961 **Air-drying insulating finishing varnish for electrical purposes.** 4s.

CLEAR, dyed or pigmented insulating varnishes, with or without added fungicide, are covered. The varnishes are not necessarily suitable for h.f. applications. General-purpose and heavy-duty grades of varnish are recognized.

B.S. 899: 1961 **Rolled copper. Sheet, strip and foil.** 6s.

REQUIREMENTS for rolled copper sheet, strip and foil in the annealed, half-hard and hard conditions, for general and electrical purposes, are given. Thicknesses up to and including 0·374 in. are covered.

B.S. 1075: 1961 **Studio spotlight lamps.** 5s.

STUDIO spotlight lamps with bi-post bases for working at 115 and 250 V and rated between 0·5 and 10 kW for black and white and colour photography and television are covered.

B.S. 1363: 1947 **Two-pole and earthing-pin fused-plugs and shuttered socket-outlets for a.c. circuits up to 250 volts.** Suppl. no. 2 (1960) —Plugs made of resilient material. 4s.

PLUGS made of a suitable resilient material, including rubber, and not included in the main specification are covered by this supplement.

B.S. 1497: Part 3: 1960 **Impregnated-asbestos-covered copper conductors.** Part 3—Round wire: metric units. 4s. 6d.

THE requirements and dimensions, in metric units, for impregnated-asbestos-covered round copper wire for electrical machinery and apparatus are given in this part of the standard. The requirements apply to wires having bare diameters from 0·25 to 5 mm inclusive.

B.S. 1522: 1960 **Projector lamps.** 4s. 6d.

TECHNICAL details are given for projector lamps of the following classes: Class A1—film projection, slide viewing, etc.; Class B1—floodlighting (round bulb); Class B2—floodlighting; Class F—microprojection; and Class T—theatre spotlight.

B.S. 1568: 1960 **Magnetic tape sound recording and reproduction.** 4s. 6d.

FEATURES of recording on magnetic tape coated on one side only are specified. Features of the tape itself and of the associated recording and reproducing equipment that are necessary to ensure satisfactory interchangeability are also specified.

B.S. 1647: 1961 **pH scale.** 4s. 6d.

THE standard applies to aqueous solutions at temperatures between 0° and 95°C and is intended to be accurate within $\pm 0{\cdot}005$ pH. A definition of the pH value of a solution is given.

B.S. 1844: Part 1: 1961 **Enamelled copper conductors** (enamel with vinyl acetal base). Part 1—Round wire. 8s. 6d.

THE requirements and dimensions for round copper wire covered with a synthetic enamel based on a vinyl acetal resin are given.

B.S. 1853: 1960 **Tubular fluorescent lamps for general lighting service.** 7s. 6d.

TUBULAR fluorescent lamps for general lighting service, with pre-heated cathodes and operating from a.c. mains with or without the use of a starter, are covered in this standard.

B.S. 2048: Part 1: 1961 **Dimensions of fractional horse-power motors** Part 1—Dimensions of motors for general use. 5s.

THE dimensions given apply to single-phase and polyphase a.c. motors and to d.c. motors having enclosures in accordance with B.S. 170 'Electrical performance of fractional horse-power motors and generators with Class A insulation'. The motors may have foot, flange or resilient-base mountings and sleeve or ball bearings.

B.S. 2050: Part 1: 1961 **Electrical resistance of conductive and anti-static products made from flexible polymeric material.** 5s.

THE articles may be made from natural or synthetic rubber, from polyvinyl chloride, from other flexible polymeric materials or from mixtures of these. The required degree of conductivity is imparted by carbon black and/or other appropriate substances added to the bulk of the material.

B.S. 2133B: Part 1: 1961 **Fixed ceramic dielectric capacitors Grade II for use in telecommunication and allied electronic equipment.** Part 1—General requirements and tests. 12s. 6d.

REQUIREMENTS and tests for fixed ceramic-dielectric capacitors Grade II having a rated voltage not exceeding 1·5 kV d.c. are given.

B.S. 2136: Part 1: 1961 **Fixed metallized-paper dielectric capacitors for d.c. operation for use in telecommunication and allied electronic equipment.** Part 1—General requirements and tests. 12s. 6d.

FIXED metallized-paper-dielectric capacitors, suitable for d.c. operation with or without a small superimposed a.c. component, are covered. The capacitors have a dielectric of impregnated paper with thin metal electrodes deposited on it. Self-healing properties are shown by the capacitors.

B.S. 2258: Part 1: 1961 **Shields for electronic tubes and valves.** Part 1—General requirements and tests. 5s.

SHIELDS for electronic valves of the types included in B.S. 448 'Electronic-valve bases, caps and holders' are covered.

B.S. 2484: 1961 **Cable covers. Concrete and earthenware.** 6s.

THERE are three parts to this specification and they relate respectively to precast reinforced concrete, unreinforced concrete and earthenware cable covers.

B.S. 2818: Part 2: 1961 **Auxiliaries for operation of fluorescent lamps on a.c. 50 c/s supplies.** Part 2—Capacitors. 6s.

CONTINUOUSLY rated capacitors of up to and including 20 μF capacity, which are intended for use in tubular-fluorescent-lamp circuits, are dealt with.

B.S. 2899: Part 2: 1961 **Rubber insulation and sheath of electric cables.** Part 2—Silicone rubber insulation. 3s.

THE composition, physical and electrical requirements, and test methods for silicone-rubber insulation, taken from electric cables after manufacture, are specified. Also included is an optional test at the core stage of manufacture for volume resistivity.

B.S. 2949: 1960 **Rotating electrical machines for use in ships.** 8s. 6d.

MARINE electric generators, motors, rotary convertors and electromagnetic slip couplings, rated at 1 hp, 0·75 kW or 0·75 kVA or greater per 1000 r.p.m., are covered by this standard. The types of enclosure that may be employed are classified.

B.S. 3188: Part 1: 1960 **Enamelled copper conductors** (self-fluxing, enamel with polyurethane base). Part 1—Round wire. 7s. 6d.

REQUIREMENTS and dimensions for round copper wire covered with polyurethane-resin-based synthetic enamel possessing self-fluxing properties are given in this part of the standard. The requirements are applicable to wires having bare diameters from 0·0016 to 0·064 in. inclusive.

B.S. 3205: 1960 **Photographic electronic flash equipment.** 4s. 6d.

THE standard covers electronic-flash equipment of the single-flash type, primarily for use with cameras in which the contacts controlling the flash are closed when the shutter is fully open. Safety requirements and performance tests are included.

B.S. 3207: Part 1: 1960 **Mineral-insulated cables.** Part 1—Copper-sheathed cables with copper conductors. 5s.

REQUIREMENTS and dimensions for copper-sheathed cables with powdered-mineral insulation and copper conductors, for general use, are given in this standard. Provision is made for a p.v.c. covering over the copper sheath, when required.

B.S. 3214: 1960 **Plugs and locking sockets for electric battery vehicles and trucks** (300 ampere rating). 4s. 6d.

PLUGS and locking sockets for extra-low-voltage (30 V a.c. or 50 V d.c.) use on electrically propelled vehicles are covered by this standard.

B.S. 3232: 1960 **Medical treatment lamps.** 5s.

THE standard applies to ultraviolet, radiant-heat and infra-red lamps intended to operate at not more than 250 V a.c. or d.c.

B.S. 3239: 1960 **Resistivity of metallic electrical conductor materials.** 5s.

ONE reference and one routine method for determining the electrical resistance and resistivity of specimens of metallic electrical conductors are described.

B.S. 3243: 1960 **Aluminium alloy conductors for overhead power transmission.** 4s. 6d.

STRANDED aluminium-alloy conductors for overhead power transmission are covered.

B.S. 3244: 1960 **Domestic pressure cookers with embedded electric elements** (safety requirements). 4s. 6d.

SAFETY requirements for domestic pressure cookers, with embedded electric-heating elements for more than 30 V a.c. or 50 V d.c. but not more than 250 V a.c. or d.c., are covered.

Technical publications (continued)

B.S. 3249: 1960 **Cables and flexible cords insulated with varnished cambric and heat-resisting fibre.** 5s.

REQUIREMENTS and dimensions for cables and flexible cords, insulated with varnished-cambric tape associated with asbestos, glass or polythene terephthalate fibre, are given. These cables are suitable for use in dry conditions where the conductor temperature does not normally exceed 85°C.

B.S. 3255: 1960 **Presspaper for electrical purposes.** 6s.

PRESSPAPER for electrical-insulation purposes is covered in this standard. The presspaper may be either dyed or of natural colour, of four different types (each of up to 20 mils thick), supplied either in roll form or as sheets cut from the roll and with a smooth calendered finish.

B.S. 3258: 1960 **Silicone-rubber-insulated cables and flexible cords.** 5s.

REQUIREMENTS and dimensions for cables and flexible cords insulated with silicone rubber, which are suitable for continuous use at a maximum temperature of 150°C, are given.

B.S. 3337: 1961 **Dimensions of plug part and lampholder for capless photo-flash lamps.** 5s.

PRINCIPAL dimensions are given. The appendix contains dimensions for recommended gauges.

B.S. 3347: 1961 **Capacitors for railway signalling track circuits.** 4s.

FIXED and adjustable capacitors for use as current-limiting and phasing impedances in railway-signalling track circuits, where the utmost reliability in service is essential, are dealt with. The railway may be electrified or not.

B.S. 3360: 1961 **Copper conductors in insulated cables and cords.** 7s. 6d.

REQUIREMENTS for plain, tinned, annealed and hard-drawn copper conductors in insulated cables and cords are given. Solid, stranded, bunched, circular and shaped conductors are covered.

B.S. 3361: 1961 **Copper conductors in insulated cables and cords (metric units).** 7s. 6d.

THIS is the counterpart, in metric units, of B.S. 3360: 1961.

B.S. 3398: 1961 **Anti-static rubber flooring.** 4s.

REQUIREMENTS for anti-static rubber flooring are specified.

B.S. 3399: 1961 **Transformers for use in ships.** 15s.

POLYPHASE and single-phase double-wound power transformers and reactors having windings insulated with Class A, B, H and/or C materials and rated from 1 to 1000 kVA inclusive are covered. The rated voltage must not exceed 3·3 kV line-to-line.

B.S. G.177: 1961 **Nyvin type electrical cables for aircraft.** 15s.

REQUIREMENTS for Nyvin-type cables are stated. Provided that the voltage between conductors, between a conductor and a metal braid surrounding it and between a conductor and the aircraft structure does not exceed 600 V r.m.s. and the frequency does not exceed 1·6 kc/s, these cables are suitable for use in aircraft circuits.

B.S. G.178: 1961 **Crimped joints (non-insulated) for general purpose electrical cables for aircraft.** 6s.

DESIGN requirements and tests are specified for the crimping of non-insulated connections for cables, with conductors of plated copper, copper alloy, aluminium or aluminium alloy, in which the stabilized conductor temperature does not exceed 105°C.

Code of practice CP327.201: 1960 **The reception of sound and television broadcasting.** 12s. 6d.

RECOMMENDATIONS for good reception of sound and television broadcasts are given.

Code of Practice CP1012: 1961 **The abatement and measurement of radio interference from electrical installations in civil aircraft.** 10s.

THE object is to make readily available the best existing information on good practice in the measurement and abatement of radio interference in aircraft. The code is intended for those concerned with the design, construction, installation and maintenance of electrical and radio equipment for aircraft or with the design, construction certification and operation of aircraft. It was prepared at the request of The Institution's Committee on Radio Equipment for Civil Aircraft.

BRITISH TRANSPORT COMMISSION

Railway electrification at industrial frequency. British Railways electrification conference, London, 1960. London, 1961. £5*

THE conference was held in London in 1960 and was attended by representatives from over 40 different railway administrations throughout the world. The book includes 42 papers and discusses the choice of the 50 c/s system in the modernization of British Railways, application of the 50 c/s system, locomotives and multiple-unit trains, power supply, overhead-line equipment, a.c.-traction research, signalling and telecommunication, and interference.

A report of the conference appeared in the November 1960 *Journal*, p. 629.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Silicones at work.† London, 1961. gratis

EMPHASIS is on industrial applications of silicones, including electrical uses.

Automatic data processing by D. W. Morley. H.M.S.O., London, 1961. 6s.

THE principles of various types of computer, their application and operation are described. Examples of data-processing are given, including the way in which the Ministry of Pensions applies automatic methods to processing the graduated-pensions scheme.

ELECTRICITY COUNCIL

Utilization research report no. 24 **First trial on the use of thermal-storage block-heaters in dwellings.** London, 1961. gratis

A TOTAL of 12 local-authority houses were equipped with improved thermal insulation. Two 1½ kW thermal-storage block-heaters were fitted in each living/dining room and a 1 kW heater in each kitchen and hall. These heaters kept the temperature of these rooms above 60°, 55° and 50° F, respectively, provided that a midday 'boost' was available and that the living/dining room temperature was 'topped up' as and when required by supplementary heating in the late afternoon and evening of cold days.

With the water heater also connected on the off-peak supply, it is estimated that such a house could be heated at an annual cost (on average tariff rates) of £60.

H.M. STATIONERY OFFICE

Cmnd. 1503 **Annual report and accounts of the British Broadcasting Corporation 1960–61.** London, 1961. 10s. 6d.

THE engineering section gives details of the coverage and reception of sound and television broadcasting. The Television Centre at Shepherds Bush is described, as well as other developments in television studios and equipment. Research and development are discussed, e.g. colour television and magnetic recording.

* Obtainable from the Publicity Officer, British Transport Commission, 22 Marylebone Road, London N.W.1
† Obtainable from the Library, Department of Scientific and Industrial Research, State House, High Holborn, London W.C.1

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Reports on progress in physics. Vol. 24 (1961). Executive editor A. C. Stickland. London, 1961. £4 4s., postage 2s.

EIGHT reports are published in this volume. They are 'The theory of the superconductive state', 'High current gas discharges', 'Cosmic radio waves and their interpretation', 'Magnetic domains', 'Photoelectronic image intensifiers', 'Ferrimagnetism', 'Theory and applications of the density matrix' and 'The dynamics of high temperature plasmas'.

Each report will be published separately in paper covers at 7s. 6d. a copy.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Publication 64 **Tungsten filament lamps for general service.** 3rd edition. Geneva, 1961 (French/English). 33s. 9d.*

THE technical requirements for tungsten-filament lamps of 100–250 V rating 25–1500 W, with a nominal life of 1000 h, are given in this publication. Methods of test to determine the quality and interchangeability of the lamps are described.

Modifications to the second edition include amendment of the conditions of compliance, introduction of gauges to ensure interchangeability and safety against accidental contact, and values for minimum rated lumens.

Publication 134 **Rating systems for electronic tubes and valves and analogous semiconductor devices.** Geneva, 1961 (French/English). 6s. 9d.*

THE object of this publication is to bring about a greater understanding of rating systems for electronic tubes and valves and analogous semiconductor devices, especially in the division of responsibility between the manufacturer and the circuit designer. Rating systems are described.

Publication 135 **Numbering of electrodes and designation of units in electronic tubes and valves.** Geneva, 1961 (French/English). 6s. 9d.*

THIS publication applies to multi-electrode tubes and valves, with the exception of cathode-ray tubes. The system used for numbering the electrodes of the same type in multi-electrode tubes and valves, and for assigning designations to the units of multiple-unit tubes and valves, is described.

MINISTRY OF EDUCATION

List of sandwich courses and block release courses in further education establishments in England and Wales 1961–62. H.M.S.O., London, 1961. 6s.

UNDER each local education authority are given the colleges running sandwich and block-release courses. The subjects read, the duration of course, the award studied for, the month of starting, the division of time between college and industry, whether the student is works- or college-based, and the entry level are listed.

NATIONAL ADVISORY COUNCIL ON THE TRAINING AND SUPPLY OF TEACHERS

Teachers for further education. Report of an Advisory Subcommittee. H.M.S.O., London, 1961. 1s. 3d.

IT is estimated that it will be necessary to double the number of full-time teachers in further education in the next ten years. An average annual recruitment of 3600 teachers will be required throughout the 1960s.

LEAD DEVELOPMENT ASSOCIATION

Production, properties and uses of lead cable sheathing. London, 1961. gratis

THE requirements of a cable sheath, lead-sheath production, lead cable-sheathing alloys, and the applications of lead sheaths to power and communication cables are discussed.

* Obtainable from the Sales Department, British Standards Institution, 2 Park Street, London W.1

Lead cable sheathing—alloy characteristics and applications. London, 1961. gratis

A PAGE is devoted to lead and each lead alloy suitable for cable sheathing. Details of composition, characteristics and the type of cable and installation for which the alloy (or lead) is suitable are given.

NATIONAL PHYSICAL LABORATORY

Notes on applied science no. 24 **Photometric standards and the unit of light** by J. S. Preston. H.M.S.O., London, 1961. 3s.

THE development of light sources from the early 19th century to the present primary standard is traced in this publication. The author describes how the N.P.L. maintains the unit of light, how it prepares and calibrates standard lamps, and how it co-operates with other official laboratories throughout the world.

POLYTECHNIC PRESS OF THE POLYTECHNIC INSTITUTE OF BROOKLYN

Active networks and feedback systems edited by J. Fox. Brooklyn, New York, 1961. 60s.*

THIS book contains the proceedings of a symposium of the same title held in New York from the 19th to 21st April 1960. The session titles were 'The state of the art and future trends', 'Feedback networks and systems', 'Synthesis of active network's, 'Active network concepts', 'Time-variable and nonlinear networks' and 'Time-varying systems'. Over 30 papers were presented.

SNOWY MOUNTAINS HYDRO-ELECTRIC AUTHORITY

The Snowy Mountains scheme. Phase 1—The Upper Tumut projects edited by W. Diesendorf. Horwitz Publications Inc., Sydney, Australia. £3 11s. 6d.

THE combined output of the Upper Tumut projects will be 600 MW. These projects are complete in themselves and form the first section of the Snowy Mountain scheme.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

AERE-R3381 **The degradation of plasticised p.v.c. compositions under high level gamma radiation—Part 2** by I. D. Aitken, H. Wells and I. Williamson. Harwell, 1961. 7s.†

THE effect of various fillers on the radiation resistance of polyvinyl chloride compositions is examined. No filler gives a better resistance than is obtained in its absence.

CLM-R7 **Toroidal discharge configurations obtained from magnetic probe methods** by E. A. Witalis. Culham, 1961. 7s.†

A METHOD of analysis is presented by which experimental results may be compared with those predicted by two theoretical models. Neither model is wholly satisfactory. Several types of discharge were found.

UNITED STATES DEPARTMENT OF COMMERCE OFFICE OF TECHNICAL SERVICES

PB 161541 **High-temperature semiconductor devices.** Radio Corporation of America, Princeton, New Jersey. $2.75‡

THIS report is a reprint of an original document resulting from Government-sponsored research. Progress made in the purification, crystal growth and evaluation of the compounds GaAs and InP is recorded. Determination of impurities in GaAs, diffusion in GaAs and InP, and minority-carrier lifetime in GaAs are discussed. The manufacture of diodes, rectifiers and transistors in both GaAs and InP is described.

* Obtainable from Interscience Publishers Ltd., 88–90 Chancery Lane, London W.C.2
† Obtainable from H.M. Stationery Office, Kingsway, London W.C.2
‡ Obtainable from the Office of Technical Services, Department of Commerce, Washington 25, D.C., U.S.A.

Technical publications (continued)

JOHN D. TROUP LTD.

The design and installation of electrically-warmed floors by L. Shepherd. London, 1961. 6s.

FOUR articles reprinted from *Heating* are presented. Heat losses and requirements in buildings; design; floor insulation and the lay-out of heating cables; and installation, temperature control and floor finishes are discussed.

WIRELESS WORLD

Guide to broadcasting stations. 13th edition. Iliffe Books Ltd., London, 1961. 3s. 6d.

ALL European long- and medium-wave and over 2000 of the world's short-wave sound-broadcasting stations are listed, both geographically and in order of frequency. European television- and v.h.f. sound-broadcasting stations with a power of 5kW or more are included.

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

GERALD CARLYLE ALLINGHAM

Gerald Carlyle Allingham, M.B.E., who died on the 26th July 1961 in Mayday Hospital, Croydon, following a fall, was born in Chelsea on the 8th November 1875, the eldest son of William Allingham, the poet. The author and historian Thomas Carlyle was his godfather. He was educated at University College School and at University College London, where he studied electrical and mechanical engineering and chemistry. He was apprenticed to Mr. D. Fitzgerald for a year.

In 1896 he became a partner in Allingham and Fennell, Leytonstone, electrical installation contractors. In 1899 he joined Stewart Electrical Syndicate Ltd. as an electrician and in 1901 joined the Tudor Accumulator Co., later becoming chief engineer.

During the 1914–18 War he served in the technical branch of the Royal Naval Division and in the Royal Engineers. He was twice mentioned in despatches and was appointed a Member of the Order of the British Empire for his wartime work. On demobilization he returned to the Tudor Accumulator Co. for two years before becoming a radio engineer with C. F. Elwell Ltd., in charge of erection of wireless transmitting plant at transmitting stations at Leafield, in the Cotswolds, and at Abu Zabal near Cairo. He joined Metropolitan-Vickers Electrical Co. in 1922 and in 1929 transferred to Britannia Batteries Ltd., in charge of the stationary- and vehicle-battery department. He joined Oldham and Sons Ltd. for a year in 1933 but returned to Britannia Batteries and was sales manager of the lead-battery division until his retirement in 1946.

He was married in 1934 and is survived by his wife and daughter.

He joined The Institution as a Student in 1894 and was elected an Associate in 1897, an Associate Member in 1902 and a Member in 1919. He was awarded a Student's premium in 1894 for his paper 'On secondary batteries'. He served as honorary secretary of the Students' Section in 1895–96. G. E. S.

WILLIAM ROY CECIL COODE-ADAMS

William Roy Cecil Coode-Adams, M.A., M.SC., PH.D., who was born on the 11th August 1895 died on the 31st May 1961. He was educated at St. Paul's School, under the late Dr. Hillard, and was a class-mate of Dr. Alexander Russell, at one time President of The Institution. He obtained a scholarship to Pembroke College, Cambridge, and took part I of the mathematical tripos in 1915. His studies were interrupted owing to the 1914–18 War, when he served in the King's Royal Rifles. As a result of his technical knowledge he was seconded to special work under the Royal Society's War Committee, and throughout his period of service with this committee he dealt mainly with explosives.

At the end of the war he resumed his studies at Cambridge and in 1921 obtained first-class honours in part II of the natural-sciences tripos. He continued at the University of Cambridge for a further three years as a demonstrator in the university chemical laboratory and during this period obtained the M.Sc. degree in 1923 and the Ph.D. degree in 1924. In connection with the latter achievement, his thesis on the optical-rotatory power of quartz was undertaken as a joint paper with Prof. Lowry.

Leaving Cambridge in 1924, he was for a short time a member of staff at Cheltenham Technical College, but in 1925 he was appointed to the staff of Faraday House Engineering College, where he served until 1957. During his association with Faraday House he became deputy principal in 1936 and was appointed principal in 1937. In 1957 he was appointed principal of the Thapar Institute of Engineering and Technology, Patiala, India, for a period of three years. Three weeks after returning to the United Kingdom he died owing to a sudden heart attack.

He was for some years a member of the Richmond Borough Council, serving on many committees, including the Library, Education, Fire Brigade and Air Raid Precaution Committees. During the Second World War he served in the Home Guard.

He published many technical and scientific papers in various journals. He is survived by his widow.

He joined The Institution as an Associate Member in 1937 and was elected a Member in 1944. G. H. R. M.

HARRY PHILIP GAZE

Harry Philip Gaze who died on the 31st July 1961 was born on the 26th April 1874. He was educated at Framlingham College, Suffolk, and at University College, Liverpool, under Sir Oliver Lodge and Dr. Hele-Shaw. He received practical training with Hills and Thompson Ltd., with the Hall Electrical Co., and in the electrical inspector's laboratory of Liverpool Corporation.

Between 1896 and 1903 he was with St. James's and Pall Mall Electric Light Co., and from 1903 to 1926 with the Central Electric Supply Co. While with the latter company he was associated with Sir Alexander Kennedy on the development of the Grove Road power station, one of the earliest stations where Willans engines with exhaust turbines were installed. In this case the plant came from the Engineering Exhibition.

In 1926 he joined the London Power Co., becoming chief generation engineer under the late Sir Leonard Pearce. In this position he was concerned with the operation of generating plant at the Battersea, Deptford and Willesden power stations, as well as at the older stations owned by the company. He retired in 1940 and joined Kennedy and Donkin in an advisory capacity.

His interests were many and varied. He was a member of the Swiss Alpine Club and for many years did a great deal of mountain climbing in Switzerland and the French Alps. He was a keen golfer and an expert gardener. He took a great interest in young people and will long be remembered for his encouragement of youth in both England and Africa.

Of late years he had lived in Rhodesia, where he was able to indulge in his hobby of a daily swim and a two-mile walk.

He joined The Institution as an Associate in 1897 and was elected an Associate Member in 1902 and a Member in 1924. H. J. B.

DATTA LAXMAN DESHPANDE

Datta Laxman Deshpande, M.SC., who died on the 5th April 1961 was born on the 2nd September 1909. He was educated at C.H. High School, Shapir Belgaum District, at Karnatak College, Dharwar, and at Baroda College.

He obtained his engineering education at Manchester University, where his career was a brilliant one, and his training with the Department of Scientific and Industrial Research, London. He returned to India in 1932 and in 1933 joined the G.B.S. Railways as assistant engineer. From 1937 to 1939 he was chief engineer of S.I. Works.

In a country where ability often fails to obtain scope, it was India's good fortune that Sir C. P. Ramaswamy Ayyar, the great Dewan of Travancore, recognized his organizing abilities and

selected him for the principalship of the new Engineering College at Travancore when he was still in his early thirties.

Thus began his lifelong association with technical institutions. From Travancore he went to the Labour Ministry to organize the Central Institute for training craft-instructors at Koni-Bilaspur. However, his finest achievement was in Bihar. The Bihar Institute of Technology was solely his creation. From a group of Nissen huts he built up an institution that is among the finest in India.

He had the gift of leadership, and everywhere his pre-eminence was willingly conceded. He had the gift of friendship too; and when men followed him, they followed him with love and loyalty. He was hardworking and never spared himself, and indeed his premature death may be attributed to overwork and his lack of concern of its effects on his health.

Those who had the fortune of being his personal friends know the warmth of his feelings, his dependability and his kind helpfulness. Nothing was too much for him to do for his friends. His hospitality knew no bounds. His geniality and easy comradeship, as much as his ability, won him a host of admirers.

He joined The Institution as an Associate Member in 1959 and was elected a Member in 1960. He was also a member of The Institutions of Mechanical and of Production Engineers and a member of the Institute of Metals. N. N. S. G.

ERIC STANLEY ELY

Eric Stanley Ely who died on the 13th July 1961 was born on the 9th May 1895. He was educated at Taunton School and received his electrical-engineering education part-time at Hartley College, Southampton, at Brighton Technical College, and at Regent Street Polytechnic. He was apprenticed to the electrical engineer's department at Southampton docks before the 1914–18 War. On the completion of his apprenticeship, he joined the 4th Hampshire Regiment and subsequently transferred to the Royal Engineers, with whom he served in India and Mesopotamia. He was commissioned in the 1st battalion, the West Riding Regiment.

In 1922 he joined Allen West, Brighton, and in 1924 became a draughtsman with the English Electric Co., London and Stafford works, before rejoining the electrical engineer's department, Southampton docks, in 1928 as senior engineer and draughtsman.

He became assistant electrical engineer in 1940 and was appointed electrical engineer in 1942. At the time of the railway regional-boundary reorganization, the docks came under separate management, and his title was changed to mechanical and electrical engineer. In addition to maintenance, post-war development and new work, he was responsible for mechanical and electrical equipment at Newhaven, Folkestone, Dover and Plymouth, and in the cross-Channel ships. He retired in 1958 and after a short holiday continued to work in his profession as a consultant.

He represented the British Transport Commission on the B.S.I. Committee for Cranes and Crane Auxiliaries and was chairman of the B.T.C. (Docks) Electrical and Mechanical Engineers' Committee.

He was very thorough in all his work and, although of serious disposition, was a pleasant personality, always ready to assist his colleagues when required. Interested in all forms of sport, he took an active interest in the Docks and Marine Club. He is survived by his widow and four sons.

He joined The Institution as a Graduate in 1926 and was elected an Associate Member in 1931 and a Member in 1947. He served on the Hampshire Sub-Centre Committee from 1934 to 1937. H. H. S.

WALTER FRANK HIGGS

Walter Frank Higgs who died on the 8th August 1961 was born at Kidderminster on the 7th April 1886. He received his technical education at Birmingham Technical Day School full-time and later part-time while apprenticed to Duckett and Brown, Birmingham. He gained further experience as assistant technical designer with H. B. Brooks, Birmingham, with the General Electric Co., Witton, with the Electrical Construction Co., Wolverhampton, and with the British Thomson-Houston Co., Rugby, before joining the Electrical Power Engineering Co., Birmingham, in 1909 for work on the design of d.c. machines.

In 1912, in partnership with his brother, he commenced the manufacture of d.c. machines. In 1924 the partnership was dissolved, and Higgs Motors moved to its present site at Witton, Birmingham, now also making a.c. motors.

He had a strong constitution, capable of sustained effort and hard work; and this was used to the full. His high sense of duty was always evident in his personal example and encouragement.

He was a councillor of the City of Birmingham and later Member of Parliament for West Birmingham. He served on the Select Committee on National Expenditure. In 1948 he became president of Birmingham Chamber of Commerce. He was a life-governor of the University of Birmingham and a guardian of the Assay Office.

He was warden at Edgbaston Old Church, Birmingham. His interests included golf, riding and walking. Later in life his periods of relaxation were spent in breeding Ayrshire cattle, in foreign travel and at the helm of his yacht; but his happiest times were occupied working at Witton and piloting the firm he founded. He is survived by his widow and two sons.

He joined The Institution as a Student in 1906 and was elected an Associate Member in 1912 and a Member in 1922. F. H.

FRANKLIN THOMAS HOMAN

Franklin Thomas Homan who died on the 2nd August 1961 was born on the 10th October 1884. He was educated at Murray's Preparatory School, Portsmouth, and at Portsmouth Grammar School and was trained as an electrical engineer at Faraday House, receiving practical experience with Robey and Co., Lincoln, and with Greenwood and Batley Ltd., Leeds.

He became assistant engineer-in-charge with Reading Electric Supply Co. in 1904 and in 1905 was appointed chief assistant engineer with Northampton Electric Light and Power Co., attaining the position of generating-station superintendent. In 1924 he became chief engineer with the Calcutta Electric Supply Corporation and early in 1928 was promoted to agent, remaining in this position until he retired in 1940. He then went to Kenya, where he built a house in Nyeri, and lived there until his death.

Under his leadership the Calcutta Electric Supply Corporation achieved considerable expansion, two new generating stations and a new head office being built, while the transmission and distribution networks were trebled.

He was a keen golfer and tennis player. He was predeceased by his wife and is survived by a son and a daughter.

He joined The Institution as a Student in 1903 and was elected an Associate Member in 1911 and a Member in 1923. J. W. C.

BURKEWOOD WELBOURN

Burkewood Welbourn, M.ENG., who died on the 1st July 1961 was born on the 13th December 1875. He was educated at Moulton Grammar School and at Framlingham College, whence he went to King's College, London, where he graduated in 1896, having served his final year as a student demonstrator under Prof. John Hopkinson.

In 1896 he spent six months as a pupil with Willans and Robinson and then became an electrical engineer with the Electro-Chemical Co., St. Helens. In 1898 he joined the British Insulated Wire Co., Prescot, as a superintendent on outside contract work. He remained with the company and its amalgamations for the rest of his career, being appointed contract manager in 1901, chief engineer in 1927 and a director in 1942, by which time the company had become British Insulated Cables Ltd. He retired from the board on the amalgamation of the company with Callender's Cables Ltd. He also served as a director of the Midlands Electricity Corporation from 1939 until the industry was nationalized.

He grasped very early the enormous possibilities of large-scale electricity distribution and encouraged the use of higher transmission voltages, anticipating the growing demands. He foresaw the demand for highly trained technical men, enrolling many onto his staff. He had a great gift for co-ordinating information, and, with his rather extraordinary memory and extreme tenacity, he made an excellent committee chairman. He travelled widely and greatly assisted his company's oversea sales organization.

He served on a number of committees for various bodies. One may single out his valuable work for the Buried Cables Research Sub-Committee and for the Lancashire Anti-Submarine Committee. In 1935 he was awarded the honorary degree of M.Eng. of Liverpool University.

He was a man of high ideals, which he lived up to with considerable success. He spent a very full life in the interests of his family, his employers, his church, and education. He is survived by his widow, four sons and one daughter.

He joined The Institution as an Associate in 1897 and was elected an Associate Member in 1902 and a Member in 1907. He served as chairman of the Manchester Local Section in 1915–16, of the Liverpool Sub-Centre in 1922–23 and of the Mersey and North Wales Centre in 1933–34. He was a member of Council from 1919 to 1922 and a vice-president from 1929 to 1932. His papers entitled 'British practice in the construction of high-tension overhead transmission lines' and 'The properties of electrolytic copper—modulus of elasticity' were published in the *Journal* in 1914 and 1918 respectively, the former being awarded a Paris premium.

SOME RECENT BOOKS

BASIC PRINCIPLES OF ELECTRONICS AND TELECOMMUNICATIONS

M. D. ARMITAGE

HARRAP. 1961. 374 PP. 22S. 6D.

THE title of this volume is undoubtedly misleading because, apart from a small section devoted to sound and microphones, there is no treatment of telecommunication. The discussion of valves, transistors and their applications must be regarded as within the field of electronics. Had the title been 'Applied electricity' it would have been more in keeping with the usual understanding of the material included.

Electric and magnetic circuits are discussed first, and the various components are considered. Although this tends to be elementary, it is a feature that many engineering students will find most helpful. Analogies are used freely, and physical interpretations in terms of more tangible things often offer a valuable picture of the process involved. The illustrations are well chosen and form a most effective background to the text. There are also excellent sections on electronics, measurement and electrochemistry.

The author and the publisher can be congratulated on having produced a well-thought-out book that should have quite a wide appeal, not only to students taking City and Guilds courses but also to those preparing themselves for more-advanced studies. H. M. BARLOW

THE MATHEMATICAL THEORY OF LINEAR SYSTEMS

B. M. BROWN

CHAPMAN AND HALL. 1961. 267 PP. £2 10S.

THIS book deals with those branches of mathematics required for an understanding or analysis of the behaviour of linear systems. The word 'system' is restricted to a mechanism where one physical quantity—voltage, speed, temperature, etc.—has a magnitude determined by a second physical quantity. The system is defined as linear if the connection between the two variables obeys the principle of superposition. Thus the scope of application of the mathematical theory is very wide. However, the author's interest and the bias of the text are towards feedback systems and automatic control. This is in fact the second volume of a series with the general title 'Automation and control engineering'.

Starting from an introduction to linear differential equations with constant coefficients, the development follows the lines of classical operational methods—Fourier series and transforms to Laplace transforms. Systems analysis is then introduced, with the complications of feedback and the problems of stability. Statistical methods are briefly described, and Wiener optimization is dealt with simply and sensibly.

Finite-difference equations lead to the Z-transform and to a discussion of sampled-data systems. The work is completed by a large number of excellent brief appendixes. Problems and examples abound, with a key to the answers. J. C. WEST

FUNDAMENTALS OF ELECTRICAL MEASUREMENTS

C. T. BALDWIN

HARRAP. 1961. 336 PP. 25S.

THIS volume is designed for the use of students up to the level of a degree or Dip. Tech. Its contents are strictly relevant to its aim, and what is not relevant is omitted. There is little pure description of constructional details, while the mathematical treatment is developed sufficiently for an understanding of fundamental principles. The style is very clear, and the student is helped by the logical sequence in which the information is presented. In a discussion of units and dimensions, the author has happily ignored those irrelevancies with which philosophically minded scientists have often befuddled an essentially simple subject.

An example of the author's care is provided by his account of a surge generator. He explains the part played by stray capacitance, without which the device would not work, a feature only too often overlooked, to the great puzzlement of the inquiring student. This is a book that can be praised and recommended without qualification. REGINALD O. KAPP

THE WAVEGUIDE MODE THEORY OF WAVE PROPAGATION

K. G. BUDDEN

LONDON: LAGOS PRESS. NEW JERSEY: PRENTICE-HALL. 1961. 325 PP. £3 10S.

DR. Budden's excellent book unifies the mathematical theory of long-range electromagnetic waves and of long-range pressure-waves in fluids. Starting from the well known theory of metallic waveguides, the author considers source excitation in detail, impulse response, effects in stratified media and effects due to imperfect guide-walls. There are also chapters on surface waves, on the effect of Earth curvature, and on advanced mathematical methods. In spite of its fundamental nature, the text is not heavily mathematical, and no one interested in these topics should find it beyond him.

The work will be of the utmost value to specialists in long-range radio and underwater sound, but to me it seems even more valuable in stressing the properties that are common to all forms of wave motion, and in showing that even rather unusual phenomena have their analogues in different aspects of wave physics. In recommending this book to the widest possible audience, I should like to express the

hope that someone will feel encouraged to treat shock waves, at present a branch of gas dynamics, in the same manner.

A. H. W. BECK

NUCLEAR ENGINEERING

G. CAHEN and P. TREILLE

NEW YORK: PRENTICE-HALL. 1961. 394 PP. £2 5S.

THIS is the successful French work 'Précis d'énergie nucléaire', now in its second edition and already translated into German and Spanish, and now into English. It is reported to have been widely used throughout Europe for final-year and postgraduate courses, and its general excellence should lead to similar use in English-speaking countries.

The original French title seems more appropriate than the translation, because the text deals primarily with the physics rather than with the engineering of nuclear plant. General modern physics, nuclear physics, reactor theory, radiation, shielding and instrumentation are very well covered and are taken to an advanced level. With such a wide range of subjects, space limitations necessitate a concise summary rather than a full development of many aspects, but this treatment is appropriate for the average professional engineer. There is a bibliography at the end of each chapter.

The engineering chapters dealing with reactor construction and applications are brief and relate largely to French and American plant described at the 1958 Geneva conference. In spite of this, the book can be strongly recommended for the clarity and soundness of the more theoretical chapters, which comprise its major part.

E. OPENSHAW TAYLOR

INFORMATION THEORY

E. C. CHERRY (*Editor*)

BUTTERWORTHS. 1961. 476 PP. £4 15S.

TEN years ago, the first interdisciplinary London symposium on information theory was organized by a small committee whose indefatigable secretary was Dr. Colin Cherry. Since then, Prof. Cherry has shouldered the main burden of planning three more international gatherings, the latest of which (1960), reported in the present volume, is a considerable tribute to his skill.

Thirty-six papers have been selected to represent fields ranging from syntactics and semantics to biological modelling. Coding and telecommunication systems have their rightful place at the start; but the striking feature of the text, apparent from a glance at the index, is the bias towards applications rather than towards the further development of the theory of information itself. Problems in such areas as psychology, physiology, and the theory of automata have bulked ever more largely in the proceedings of successive symposia.

In itself this is highly desirable and an encouraging token of the catalytic power of the new ideas. It could be regretted only if it gave the impression that the main edifice of information theory itself is substantially complete. The truth is to the contrary, as attested by the growing restiveness of would-be users whose problems do not happen to reduce to the standard form treated by Shannon. A wider analysis of informational concepts is required to meet even the present needs of experimental psychologists, electrophysiologists, linguists and others. It may be hoped that this stimulating book will play its part in tempting suitable workers to the task.

D. M. MACKAY

PROGRAMMING COMPUTERS FOR BUSINESS APPLICATIONS

N. CHAPIN

McGRAW-HILL. 1961. 279 PP. £2 18S.

AFTER outlining the functional blocks of a computer in the first few pages, the author deals directly, though in an elementary way, with preparation for programming. Real work begins in chapter 4 on the use of COBOL (Common Business Oriented Language) with Univac III, IBM 7070 and IBM 1401, the object being the translation of a programme from English into COBOL.

The bulk of the text is concerned with development programming and with techniques aimed at achieving accuracy, speed and economical storage. There follow a discussion of subroutines and a library of programmes.

Useful appendixes contain a condensed repertoire for COBOL, the IBM 7070 Autocoder, the IBM 1401 symbolic programme and the Burroughs 220 BLEAP. There is also a glossary, which, strangely, does not include the word COBOL.

The volume is well written and easy to read, and programmers will find it useful.

A. T. STARR

ELECTROMECHANICAL COMPONENTS FOR SERVOMECHANISMS

S. A. DAVIS and B. K. LEDGERWOOD

McGRAW-HILL. 1961. 338 PP. £4 9S.

THIS book deals with *rotating* components for servomechanisms and tacitly assumes that linear motion will be obtained with rack and pinion. Chapters cover potentiometers, synchros, resolvers and induction potentiometers, tachometers, a.c. servomotors, d.c. control motors and other components. Some account of the present accuracy of the devices is given, their theory and equivalent circuits are treated, and their relative virtues and vices are tabulated. Attention is paid to the problem of estimating from manufacturers' data sheets the information that is not given.

The text should prove extremely useful to the engineer needing to use such devices for the first time and has many stimulating ideas for engineers already familiar with them.

D. B. WELBOURN

TIME RELAYS

G. V. DRUZHININ

PERGAMON PRESS. 1961. 80 PP. 15S.

TRANSLATED from the Russian, this handbook for automation engineers describes many ways of providing relays with time-delays. The first chapter deals with relays having electrical

delays and includes electronic and magnetic amplifier circuits. The three other chapters cover mechanical, thermal and electrochemical delay techniques respectively. Tables are included that give useful guidance on the performance range of the different types of relay, despite the fact that the type numbers, which probably refer to relays of Russian manufacture, are of little use.

Much of the subject-matter is already well known to those accustomed to working with relays; e.g. the telephone relay with copper slugs is fully discussed. Nevertheless, the use of relays is so widespread that engineers not specialized in the field may find this little book a useful summary of existing practice.

F. C. WIDDIS

FREQUENCY MODULATION THEORY: APPLICATION TO MICROWAVE LINKS

J. FAGOT and P. MAGNE

PERGAMON PRESS. 1961. 488 PP. £5

THE title is somewhat misleading: a more appropriate one would be 'Microwave links—with particular reference to frequency modulation'.

The text is in five parts, with references at the end of each. The first part deals with the transfer of radio energy over a given path, consideration being given to its variation with frequency, directness of path and diffraction, and tropospheric scatter. Part 2 considers standard f.m. theory, the spectrum of an f.m. wave, the advantages of frequency modulation in terms of signal/noise ratio, and distortion in amplifiers. The third part is concerned with distortion in propagation, both in free space and in a badly matched feeder. Part 4 examines the problem of transmission of telephony and television over links, consideration being given to international standards. The last part discusses radio-link equipment, general problems being studied in detail.

The treatment of propagation is of general interest, one section on line-of-sight links being particularly appropriate, while the brief summary of tropospheric scatter is quite successful. A wealth of experimental data is included that can be found elsewhere only in original papers. The description of radio-link equipment, occupying half the book, could well be out of date in a few years. The depth of treatment of the topics is very variable; one would have expected, for example, more than a passing mention of the use of ferrites.

The illustrations and graphs are clear and numerous, and the French authors have even troubled to draw the circuit diagrams in a style familiar to British engineers.

E. RIBCHESTER

PRINCIPLES OF LINEAR NETWORKS

B. FRIEDLAND, O. WING and R. ASH

McGRAW-HILL. 1961. 270 PP. £3 9S. 6D.

THIS treatise, based on the lecture notes used by the authors at Columbia University, opens with a useful discussion of polarity conventions and the properties of circuit-elements. To emphasize that the principle of superposition is fundamental to the theory of all linear systems, this principle and its corollaries, Thévénin's and Norton's theorems, are discussed early in the book.

A short account of topological methods in relation to networks is followed by chapters devoted to analysis by means of loop currents or nodal voltages, single-energy and double-energy transients, and networks in the sinusoidal steady state.

The two final chapters introduce pole-zero methods, sinusoidal frequency characteristics of networks, decibel notation, simple filter circuits and, briefly, the general theory of four-terminal networks.

Laplace-transform methods have been deliberately omitted, and there is no mention of non-sinusoidal waveforms or the method of symmetrical components. A minor criticism is that the treatment of the delta-star transformation seems unnecessarily long, and the reverse transformation can be effected quite simply in terms of admittances.

The necessary mathematical equipment does not go beyond the elements of algebra, complex numbers and simple differential equations. There are many exercises (without answers); and the book may be recommended as an easy introduction to linear networks, suitable for the second year of an engineering-degree course in the United Kingdom.

S. A. SWANN

ANNUAL REVIEW IN AUTOMATIC PROGRAMMING—Vol. 2

R. GOODMAN (*Editor*)

PERGAMON PRESS. 1961. 394 PP. £3 10S.

PROGRAMMING AND CODING FOR AUTOMATIC DIGITAL COMPUTERS

G. W. EVANS II and C. L. PERRY

McGRAW-HILL. 1961. 249 PP. £3 14S.

WITHIN the last few years, the development of automatic programming systems has increased enormously. An indication of the amount of work that is now going into the development of compilers is given by the fact that Vol. 2 of 'Annual review in automatic programming' runs to nearly 400 pages. It sets out to show modern trends rather than to give an exhaustive survey, and in this it succeeds admirably. The papers, written by experts in countries ranging from Poland to the United States, cover both scientific and business compilers. They describe systems designed for specific machines and systems that are deliberately designed to be computer-independent. Comparisons between, and critical discussions of, the various systems are included.

Whereas the 'Annual review' is written essentially for specialists who wish to keep up with current developments in the field, 'Programming and coding for automatic digital computers' is of a different nature. As the authors state in their preface, it is an appropriate college text for courses on programming and coding. Without referring to any specific machine, they deal with the fundamentals of

conventional coding for present-day machines. They give a thorough treatment of number representation, arithmetic operations, preparation of flow diagrams, and use of subroutines. They discuss in less detail logical design, numerical analysis, and the organization of a computer installation.

C. M. POPPLEWELL

ITERATIVE ARRAYS OF LOGICAL CIRCUITS

F. C. HENNIE III

JOHN WILEY. 1961. 242 PP. £2

IN a modern electronic digital computer, roughly half the cabinet volume is taken up by transistor logic panels, the rest being allocated to back wiring. Within a few years the transistor panel will be replaced by a semiconductor assembly one-fiftieth the size. The obvious next stage will be to scale down the back wiring and automate its fabrication. One way of approaching the wiring problem is to restrict the interconnections, allowing only a limited number of nearest-neighbour connections. The computer units then become a two- or three-dimensional mesh of connecting wires, with a logic element at each intersection. If, in a particular unit, the logic elements are identical, they form an iterative array of logical circuits.

Based on a doctoral thesis, this monograph sets out to explore in detail the theory of iterative logical arrays. Many valuable new results are presented. The first half is devoted to fundamental theory, the main conclusion being that multi-dimensional arrays are undecidable, i.e. that there is no general method of deducing equivalence between different arrays or of deciding whether (or how) an array will run to an equilibrium state from given initial conditions. In the second half, some specific synthesis problems in one-and two-dimensional structures are discussed. For specific situations it is possible to discuss the equivalence and decomposition of different arrays. An exchange between the space and time dimensions, related to serial and parallel working, can also be deduced.

The exposition is exceptionally clear. A particularly commendable feature is that no specialized mathematical or logical notation is employed. State and transition matrices are used only where strictly necessary, and the meaning of their elements is plainly indicated. There are many simple block diagrams—not the involved logic diagrams so popular a few years ago. Throughout, the author is careful to point out the gaps in present knowledge, which cover questions of real practical significance. New semiconductor components, and the need to automate the design of computer control units by using a computer to do the designing, will together accelerate the development of logical theory, to which this book is an important contribution.

Many publishers in the cybernetics field are issuing an inordinate number of volumes of inflated size and price, usually covering very old ground and treating an excessive field inadequately. It is a pleasure to be able to compliment the present publishers on producing a compact treatise on a well defined topic, with every page at a high level.

J. J. FLORENTIN

ANTENNA ENGINEERING HANDBOOK

H. JASIK (*Editor*)

McGRAW-HILL. 1961. 849 PP. £8 10S. 6D.

THE 35 chapters of this book, written by 39 contributors, cover all the types of antenna that an ambitious designer can think of.

The first two chapters deal with fundamentals, the next 16 treat the properties of different antennas without regard to their applications, a further 11 are concerned with applications, and the six final chapters discuss topics associated with antennas. This is a comprehensive treatment indeed, and the only addition I can suggest is a chapter in the application section on the subject of microwave-relay antennas.

Topics more amenable to mathematical analysis are given some priority. The best example of this can be found in chapter 2, where Woodward's elegant synthesis technique is described in a few pages (however, none of the shaped-beam antennas mentioned in the text was designed by that method). Similarly, in a few chapters there is great emphasis on principles, at the expense of design curves and tables. Some of them are more in the nature of survey papers than the condensation of design information which one would look for in a handbook. So the volume is of little use to the engineer who would like to design an antenna in an afternoon. It would, however, be of considerable help in choosing the type of the antenna most suitable for a given purpose, and it will also prove useful to the systems engineer who wishes to assess the capabilities of antennas.

L. SOLYMAR

PHYSICS FOR ELECTRICAL ENGINEERS

W. P. JOLLY

ENGLISH UNIVERSITIES PRESS. 1961. 308 PP. 21S.

THIS book is attractively written. It covers selected topics only—those required by students qualifying in electrical engineering. For example, the resolving power of optical instruments is discussed, but not the general properties of lenses. Even so, to compass what is attempted within 300 pp. is a formidable undertaking. Inevitably the treatment is extremely brief in places and lacks historical reference, so that it often seems too dogmatic (this is especially noticeable in the opening chapters on atomic theory).

Besides students, qualified engineers wishing to keep their physics up to date will read the text with profit and be stimulated to further reading where fuller information is desired.

A. W. V. MACE

NUCLEAR POWER

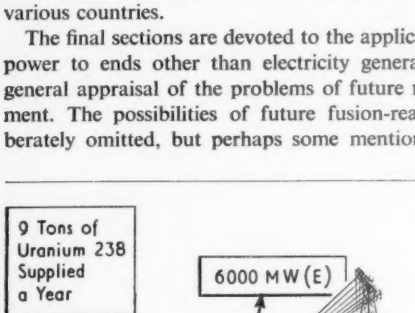
K. JAY

METHUEN. 1961. 270 PP. 25S.

ALTHOUGH in the foreword Sir Roger Makins states that it is intended for the layman, the book will undoubtedly make excellent background reading for both student and practising engineer. The bulk of the text describes the main power-reactor systems that have been either constructed or examined in some detail.

To set the scene, the first five chapters are designed to elucidate briefly the broad principles of such topics as the concept of energy and the fission process, types of nuclear fuel and fuel cycles, the economics of nuclear power, and the reasons for the existence of nuclear power programmes in various countries.

The final sections are devoted to the application of nuclear power to ends other than electricity generation, and to a general appraisal of the problems of future reactor development. The possibilities of future fusion-reactors are deliberately omitted, but perhaps some mention of the direct conversion of fission heat to electrical energy without an intermediate thermal cycle would have been of value in the latter chapters.


9 Tons of Uranium 238 Supplied a Year
6000 MW (E)
BREEDER REACTOR
CONVERSION RATIO=1·4
9 Tons of Fission Products (Waste)
12·6 Tons of Plutonium
9 Tons of Plutonium Recycled a Year
3·6 Tons to Store

Fuel utilization in a hypothetical fast-breeder-reactor cycle

The author writes in his usual competent and lucid style; occasionally there is some repetition, but this will be of value to some readers. Most of the sections are rounded off by a useful summary, and a selected list for further reading and a glossary of technical terms are included in the appendixes. The diagrams are clear and informative, and there are 16 photographic plates.

E. HOLLAND

FOURIER TRANSFORMS

R. C. JENNISON

PERGAMON PRESS. 1961. 120 PP. 30S.

THIS short book describes the principles and some of the practical uses of the Fourier transformation, with examples drawn mainly from optics and electronics.

The Fourier transform is formally stated and is used to obtain the transforms of the delta and rectangular functions. A short list of common Fourier pairs follows, some being constructed from the elementary delta function while others are derived later in the text. Further work covered includes the convolution theorem, the differentiation of Fourier transforms, and the autocorrelation function. Tables of useful functions are appended. Many diagrams are employed to clarify or to develop the topics under consideration.

Because the book is intended for the experimentalist, the accompanying mathematical work is elementary; but the reader whose approach to Fourier transforms is predominantly mathematical will find much of interest throughout.

F. H. JACKSON

TRANSISTOR CIRCUIT ANALYSIS

M. V. JOYCE and K. K. CLARKE

READING, MASS.: ADDISON-WESLEY. 1961. 461 PP. £4 1S.

THE authors' aim was to produce a textbook free from confusing details of device construction and physics, using only those methods of circuit analysis that have proved the most profitable. They have successfully achieved this. The result is a book that can be thoroughly recommended to advanced students intending to enter the field of transistor applications and that could be used as a standard work of reference by the practising circuit designer. It will provide him not only with a comprehensive analysis of most types of standard transistor circuit but also with an excellent background understanding of the features of semiconductor devices that may limit the performance obtainable from those circuits, such as noise, thermal time-constant, transient breakdown, charge storage, etc.

The first chapter gives a concise survey of the physical principles of semiconductor-device operation, followed by sections on equivalent-circuit development, d.c. biasing and thermal stability. These principles are applied in the next three chapters to the design of low-frequency and power amplifiers and regulated power supplies. Equivalent circuits are further developed to include high-frequency and noise effects. Two sections discuss the design of video and narrow-band h.f. amplifiers. The remainder is mainly devoted to pulse-circuit analysis, based on a large-signal equivalent circuit derived from excess minority-carrier density considerations.

Each chapter is followed by a set of design problems and a comprehensive list of references. The problems are an important part of the text, as they are similar to those encountered in practice by the professional circuit designer.

In view of the untimely death, in 1958, of M. V. Joyce, his co-author, K. K. Clarke, is to be congratulated on producing a work that is so complete and up to date.

J. A. INGHAM

ELECTROMECHANICAL SYSTEM THEORY

H. E. KOENIG and W. A. BLACKWELL

McGRAW-HILL. 1961. 504 PP. £5 12S. 6D.

THE book sets out to co-ordinate several branches of engineering that are at present treated as separate subjects, such as static networks, rotating machines, control systems and power systems. The proposed comprehensive 'discipline of

engineering' is wide enough to cover hydraulic and thermal, as well as electromechanical, systems.

The preface states that the key to the discipline lies in the concept of a 'linear graph'. The term is taken from the language of topology, in which 'graph' means 'a set of oriented line segments'. The word 'linear' refers to the representation by lines, and the theory does in fact apply fully to non-linear conditions. The main theme of the text is the quite straightforward one that a comprehensive analysis on any of these systems requires the setting-up and solution of sets of equations relating the variables.

Altogether the book is an important one, worthy of study by all concerned with system analysis, both for its philosophical content and as presenting a method of practical value.

B. ADKINS

TRANSIENT CIRCUIT ANALYSIS

Y. H. KU

NEW YORK: VAN NOSTRAND. 1961. 441 PP. £3 19S.

THIS is a graduate-level text on transient analysis and related topics. It includes some basic network theory, the classical solution of differential equations, some function theory, Fourier series, and Fourier and Laplace transforms and their elementary application to lumped networks, transmission lines and sampled-data systems. It may be distinguished from earlier works on these topics by its inclusion of some newer transform methods applicable respectively to non-linear, varying-parameter, discrete and random-signal problems. These are presented in the appendixes by reprinting several recent papers by the author and his associates. The methods are not assimilated into the main text, nor are they illustrated by examples; thus, despite their inherent interest, the average reader will find them rather indigestible. In the main body of the work, however, the pace and style are more tutorial.

As often happens, the ramifications of Fourier analysis are better treated than the roots. It is to be hoped that the same old hazy transition from Fourier series to Fourier integral will not find its way into many more textbooks as the only justification of Fourier's theorem. Meanwhile, the serious student is recommended to complement his reading of this or any similar book by a study of Prof. Lighthill's 'Fourier analysis and generalized functions'.

K. W. CATTERMOLE

COMPUTER CONTROL SYSTEMS TECHNOLOGY

C. T. LEONDES (*Editor*)

McGRAW-HILL. 1961. 649 PP. £6 4S.

THIS work is the outcome of a series of seminar lectures. It is in three, virtually independent, parts. There are about 20 contributing authors; and, while there is an underlying pattern, they provide a fairly mixed bill of fare. The first part is concerned with computers, both digital and analogue. It represents an initiation into the mystique of computers, starting from first principles. Interpretations of jargon are given freely, and some of the contributors indicate the most recent advances in technique. This rapid transition from the elementary to the advanced, although understandable in a seminar, is a little disturbing.

The second part is concerned with control systems and again is comprehensive in its coverage, starting from an elementary level. Professionally, it is perhaps the most useful section of the book: it includes a good review of sampled-data theory and concludes with an important paper by Zadeh on optimal-control problems. The specialist may well grieve that some of these contributions are not available independently, since he is unlikely to wish to be encumbered by the entire volume for the sake of his particular interest.

The final part is concerned with applications to complex systems. This is very well done, since the contributors are professionally associated with the applications they discuss. Interesting control applications considered include navigation and guidance, air-traffic control, control in nuclear reactors, automatic machine-tool control, and control in process industries. This section is perhaps the best part of the text.

The contributions are insufficiently long for real detail to be discussed, and perhaps this is not desirable in a work of this kind. As a survey for initiates, of what control theory can do, it is very good indeed. They are the people for whom the book is essentially intended; they are in fact the people to whom the original seminars were addressed.

J. H. WESTCOTT

INTRODUCTION TO MICROWAVE PRACTICE

P. F. MARINER

LONDON: HEYWOOD. 1961. 238 PP. £2 10S.

THE core of the book, some 120 pp., covers fundamental measurement techniques for the transmission of power by waveguide and is concerned with the low-power test bench rather than with systems engineering. The clear descriptive approach supported by quite elementary mathematics will enable the principles of the techniques employed to be easily grasped by technicians new to this work. Information on essential measurement precautions and component-fabrication difficulties is nicely inserted as appropriate. Occasional loose statements appear as the author searches for the simplifying phrase, but the information presented is almost always accurate and reliable.

The remainder of the text consists of a discussion of waveguide and transmission-line principles and a series of mathematical appendixes on vector algebra and field equations. The appendixes seem out of context and, in fact, have been included as preparation for a more advanced volume now being prepared. Early chapters on elementary transmission principles describe the plane-wave method of synthesizing waveguide modes, illustrated by some elaborate, sometimes confusing, field and wall current distribution diagrams. A good chapter on lines, impedance concepts and circle diagrams lays the foundation for the main work on measurement. Certainly this is a useful book for the microwave 'apprentice plumber'. His 'master' ought not to need the guidance of its pages.

R. G. HULSE

FUNCTIONAL CIRCUITS AND OSCILLATORS

H. J. REICH

PRINCETON: VAN NOSTRAND. 1961. 466 PP. £4 14S.

THIS work covers much the same ground as the well known volume on 'Waveforms', which was published 12 years ago in the Radiation Laboratory Series. It deals with all those circuits that are used to generate the waveforms required in the various applications of electronics. Although the earlier work is a classic, it was written before the advent of the transistor, and so there was need of a further text to describe more-recent developments. This the present volume does most successfully.

The author bases his treatment on the properties of negative-resistance networks and whenever possible explains the behaviour of other circuits in terms of these properties. This is a most welcome feature, which has not previously been developed to the same extent. It provides a connecting link between circuits that at first sight have little in common and prevents the book from degenerating into a mere catalogue.

Although the treatment is largely non-mathematical, it is by no means superficial, and the reader is encouraged to supply the missing algebra by solving a considerable number of problems. This is an excellent book, which will be used principally as a work of reference. C. W. OATLEY

WAVE PROPAGATION IN A TURBULENT MEDIUM

V. I. TATARSKI

McGRAW-HILL. 1961. 285 PP. £3 16S.

THIS book has been ably translated from the Russian by R. A. Silverman, and we are greatly indebted to him for making so much important original work available to the English reader. However, only the statistical expert will be able to appreciate all the mathematical details of the description of random fields and turbulence theory in part 1, where the author lays the foundations of his subject.

Radio engineers will be more familiar with some of the results in part 2, dealing with the scattering of electromagnetic and acoustic waves. Maxwell's equations are solved by a perturbation method in an analysis of the various scattering theories and their limitations, and in part 3 the argument is enlarged to consider amplitude and phase fluctuations of a monochromatic wave.

The experimental data in part 4 will appeal most to the engineer, especially the investigation of the scintillation of terrestrial light sources in relation to the parameters determining the structure of the atmosphere. The final discussion on the scintillation of stars is again severely mathematical, and the engineer will have to do a lot of hard work before he can apply the findings of this volume to his radio-meteorological problems. Nevertheless, it is a most valuable record of some outstanding work and should be in every research library covering the field. G. MILLINGTON

CYBERNETICS

N. WIENER

JOHN WILEY. 2ND EDITION. 1961. 212 PP. £2 12S.

THE second edition of this well known book contains the whole of the original edition, with typographical errors removed; two chapters have been added: 'On learning and self-reproducing machines' and 'Brain waves and self-organizing systems'.

The general style remains unchanged; the work is addressed to the intelligent layman but contains islets of pure mathematics readable only by specialists. Both editions are valuable in introducing to a wide public those physical sciences that are beginning to contribute to our understanding of the nature of man and his society; they also partake of the nature of autobiography and give a picture of a most interesting personality. But we do not go to 'Cybernetics' for scientific information; this is best found in professional journals and, indeed, in other publications of Prof. Wiener.

The two new chapters discuss chess-playing machines, Prof. Gabor's learning filters, sampled autocorrelation functions of Brownian variables, war, bullfights and magic. The discussion of self-reproduction contains no mention of the Crick–Watson theory of gene-splitting; there is little reference to recent work on self-adaptive control.

From the hermit's cave Hermite polynomials emerge, but a selection principle by which new facts are admitted is difficult to discover. A. M. UTTLEY

AIRCRAFT INSTRUMENTS

C. A. WILLIAMS

ODHAMS. 1961. 240 PP. 35S.

MR. Williams has set out to write a book on the aircraft instruments that are the concern of the operators' instrument engineer or of those who wish to qualify in that field, and he has provided an excellent guide. He is to be congratulated particularly on the clarity of his written descriptions and on his restraint in omitting the mathematical theory behind the instrumentation. From the point of view of the general reader, however, the artificial selection of the instruments included is disappointing, because a substantial number of modern instruments have been omitted.

The volume is well produced and well illustrated by photographs and diagrammatic sketches. The general-arrangement drawings of instruments have, however, suffered by having been reduced in size, in some cases to the point where they are no longer useful; for instance, a diagram of a maximum-air-speed indicator is complicated enough without being reduced to about one-third full size.

Nevertheless, this is as clear and concise a text as the instrument engineer is likely to get; and, within its scope, it is readily acceptable to the general reader. J. C. RIVETT

** Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

LIBRARY ACCESSIONS

BOOKS

BLAKE, R. F. (*Editor*) 621.318.572

Static relays for electronic circuits*

New York: Reinhold. London: Chapman and Hall, 1960. pp. viii, 198. 23 × 15cm. £3 3s.

Deals with electronic, semiconductor and ferromagnetic switching devices. There are chapters on bistable magnetic-amplifier switches, a triggered oscillator-controlled switch using junction transistors, solid-state analogue switching circuits, static power relays, contactors and circuit-breakers, and the photocell switch.

BUDDEN, K. G. 551.510.5

Radio waves in the ionosphere: the mathematical theory of the reflection of radio waves from stratified ionised layers*

Cambridge University Press, 1961. pp. xxiv, 542. 23 × 15cm. £4 15s.

Reviewed in the July 1961 *Journal*, p. 459.

CARNT, P. S., and TOWNSEND, G. B. 621.397.3

Colour television: N.T.S.C. system, principles and practice*

London: Iliffe Books, 1961. pp. xiii, 487. 21·5 × 14cm. £4 5s.

A comprehensive account of the N.T.S.C. system and the British and Continental versions from the point of view of the receiver engineer. Differences between the 405-, 525- and 625-line systems are explained. Among the subjects covered are colour-picture tubes, cameras and film scanners, transmitter coding, coding circuits, receiver design, decoding circuits, reference-frequency generators, operation of the shadow-mask tube, testing, installation, fault-finding, and monochrome reception. To be reviewed.

CLARRICOATS, P. J. B. 621.318

Microwave ferrites*

London: Chapman and Hall, 1961. pp. xi, 260. 24·5 × 15·5cm. £2 10s.

A full account of the theory of electromagnetic-wave propagation through ferrite-loaded waveguides and a survey of the operation, performance and design of ferrite devices. The general properties and intrinsic microwave properties of ferrites and the subject of magnetic losses are discussed. Reviewed in the October 1961 *Journal*, p. 622.

FRADIN, A. Z. 621.396.67

Microwave antennas*

Pergamon Press, 1961. pp. xii, 668. 21·5 × 14cm. £5 5s.

This translation from the Russian explains the fundamental theory of the subject and classifies and describes the various types of microwave antenna as horn, lens, slot, dielectric, reflector, surface-wave and helical. Rigorous and approximate methods of analysis are given, together with mathematical solutions of a number of problems. Reviewed in the July 1961 *Journal*, p. 461.

GRIDLEY, J. H. (*Editor*) 621.316

High voltage distribution practice: a symposium*

London: Ernest Benn, 1961. pp. 240. 23 × 15·5cm. £2 5s.

A collection of lectures, given at the Regent Street Polytechnic by a number of senior engineers, on the planning, mechanical design and erection of overhead lines, substations, protection of distribution systems, lightning protection, and operation and maintenance of equipment. Reviewed in the November 1961 *Journal*, p. 673.

HARPER, C. A. 621.3.049

Electronic packaging with resins: a practical guide for materials and manufacturing techniques*

New York and London: McGraw-Hill, 1961. pp. xii, 339. 23 × 15cm. £4 5s. 6d.

Deals with polyesters, epoxy resins, silicones, urethanes, polysulphides and other materials, with essential data, although these are related to American trade names. Reviewed in the September 1961 *Journal*, p. 574.

HUBERT, C. I. 621.31

Operational electricity: theory, characteristics, applications, and mode of operation of circuits and machines*

New York and London: John Wiley, 1961. pp. x, 530. 23 × 15cm. £3 8s.

In this book the usual method, of dealing first with d.c. circuits and machines and then going on to a.c. systems, has been abandoned in favour of a unified treatment. Direct current is treated as a special case of alternating current. Generators, motors, transformers and controls, including magnetic controllers, are discussed, and there are questions and answers on each chapter.

JASIK, H. (*Editor*) 621.396.67

Antenna engineering handbook*

New York and London: McGraw-Hill, 1961. pp. xi, 849. 23 × 15cm. £8 10s. 6d.

This is a mammoth compendium of principles, applications, and design data on all types of aerial, with extensive bibliographies at the end of each chapter. Reviewed on p. 757.

KOENIG, H. E., and BLACKWELL, W. A. 621–52

Electromechanical system theory*

New York and London: McGraw-Hill, 1961. pp. xvi, 504. 23 × 15cm. £5 12s. 6d.

Describes the preparation of network diagrams and linear graphs for electrical and mechanical components and assemblies, for the analysis and design of control systems embracing electrical, mechanical and hydraulic equipment. Reviewed on p. 758.

KORN, G. A., and KORN, T. M. 51

Mathematical handbook for scientists and engineers: definitions, theorems, and formulas for reference and review

New York and London: McGraw-Hill, 1961. pp. xiv, 943. 23 × 15·5cm. £7 15s.

A comprehensive collection of definitions, theorems and formulas. Besides being a reference work, this volume is intended as a survey of methods useful beyond specialized applications. The most important formulas and definitions are grouped together for emphasis and rapid reference. The main text is in large type, with more-detailed and advanced matter in small type; there are bibliographical references for further reading. Reviewed in the August 1961 *Journal*, p. 523.

LEONDES, C. T. (*Editor*) 621–52

Computer control systems technology*

New York and London: McGraw-Hill, 1961. pp. x, 649. 23·5 × 15·5cm. £6 4s.

The first part of this book deals with the theory of digital and analogue computers, the second with control theory, and the third with applications to complex systems. These include navigation, guidance and control of space vehicles, air-traffic control, control problems in nuclear reactors, automatic machine-tool control, and computer control in process industries. Reviewed on p. 759.

Library accessions (continued)

LOWRY, H. R., and others 621.315.59

General Electric tunnel diode manual*

Liverpool, New York: General Electric Company, 1961. pp. 96. 21·5 × 13cm. 12s.

Deals with the theory, ratings and characteristics of tunnel diodes and their application in amplifiers, oscillators, switches and logic circuits. Tunnel-diode test circuits are described.

McCLEERY, D. K. 538.551

Introduction to transients*

London: Chapman and Hall, 1961. pp. ix, 232. 21·5 × 14cm. £2 2s.

The standard method applied to the study and teaching of transient phenomena is the Laplace transform. This work offers a new look at a simpler, if mathematically less rigorous, approach by the operational calculus of Heaviside. Reviewed in the November 1961 *Journal*, p. 676.

POVEJSIL, D. J., and others 621.396.96

Airborne radar*

Princeton and London: Van Nostrand, 1961. pp. xx, 823. 23 × 15·5cm. £6 11s. 6d.

This book deals with the problems that arise when radar systems and components have to be designed for airborne installation. It discusses the requirements of such systems, noise, antennas, components, mechanical design and packaging problems. Reviewed in the August 1961 *Journal*, p. 524.

PRIAROGGIA, P. G., and others 621.315.2

Fundamentals of the theory of paper lapping of a single core high voltage cable

Milan: Pirelli S.p.A., 1961. pp. 135. 21 × 14cm. n.p.

It is necessary to bend a cable round a drum of relatively small diameter during manufacture and laying. This produces mechanical and electrical problems when paper lapping is used. A design theory that has proved successful in practice is described.

SCHLICKE, H. M. 621·318

Essentials of dielectromagnetic engineering: an introduction to the thinking in and the use of ferrites and high-permittivity dielectrics*

New York and London: John Wiley, 1961. pp. xxii, 242. 23 × 15cm. £3 16s.

Reviewed in the August 1961 *Journal*, p. 524.

SESHU, S., and REED, M. B. 538.551

Linear graphs and electrical networks*

Reading, Mass., and London: Addison-Wesley, 1961. pp. x, 315. 22·5 × 15·5cm. £3 14s.

The first five chapters are devoted to the basic theory of graphs. The remainder deals with applications, including network analysis and synthesis and the theory of switching. This is a book for advanced students who can cope with the mathematics used. Reviewed in the August 1961 *Journal*, p. 525.

WESTINGHOUSE ELECTRIC CORPORATION 621.315

Electric utility engineering reference book. Vol. 3—Distribution systems*

East Pittsburgh: Westinghouse Electric Corporation, 1959. pp. 567. 28 × 21·5cm. £4 4s.

This is the first volume to be published of this new work, which is intended as a companion to the classic 'Electrical transmission and distribution reference book'. Vol. 1 is entitled 'System analysis and generation' and Vol. 2 'Transmission and system protection'. Various authors have co-operated in this work. The present volume examines load characteristics, substations, primary and secondary networks, transformers, voltage regulation, use of capacitors, fluctuations on power systems, protection, metering and street lighting.

SIMPSON, P. G. 621.365.5

Induction heating: coil and system design*

New York and London: McGraw-Hill, 1960. pp. viii, 295. 23 × 15·5cm. £4 9s.

Outlines design procedure for coils, power systems and generating and control equipment for typical applications, having regard to economy as well as to technical considerations. Reviewed in the August 1961 *Journal*, p. 525.

VUYLSTEKE, A. A. 621.375.9

Elements of maser theory*

Princeton and London: Van Nostrand, 1960. pp. xiii, 362. 23 × 15·5cm. £3 11s. 6d.

The first part deals with quantum theory, statistical mechanics, and the interaction of radiation with matter. The second half examines the theory of two- and three-level masers, the ammonia maser, the paramagnetic solid maser, and maser noise. Reviewed in the August 1961 *Journal*, p. 526.

WAINWRIGHT, L. F. 629.135

Aircraft electrical practice*

London: Odhams Press Ltd., 1961. pp. 320. 22 × 15cm. £2 5s.

The special requirements of aircraft equipment are discussed. Weight, durability, reliability and the effect of environmental factors such as pressure, temperature and vibration are mentioned. The various parts of complete power systems and ancillary electrical equipment are considered. To be reviewed.

WESTWATER, F. L., and WADDELL, W. A. 621–52

An introduction to servomechanisms*

London: English Universities Press Ltd., 1961. pp. x, 191. 21·5 × 14cm. 15s.

Explains the basic theory of the subject, first mathematically but without recourse to anything more advanced than differential equations, then graphically by frequency-response methods. Reviewed in the October 1961 *Journal*, p. 627.

WHITESITT, J. E. 512

Boolean algebra and its applications*

Reading, Mass., and London: Addison-Wesley, 1961. pp. x, 182. 23·5 × 16cm. £2 11s.

The algebra of sets is described, as an introduction to Boolean algebra. Applications to symbolic logic, switching circuits, control problems, computers, and probability theory are discussed. Worked examples and problems (with answers) for the student to solve are included. Reviewed in the September 1961 *Journal*, p. 575.

WIENER, N. 621–52

Cybernetics, or control and communication in the animal and the machine. 2nd edition*

New York and London: M.I.T. Press and John Wiley, 1961. pp. xvi, 212. 23 × 15·5cm. £2 12s.

Originally published 13 years ago, this is a revised edition with two additional chapters, one on learning and self-reproducing machines, the other on brain waves and self-organizing systems. Reviewed on p. 760.

WILLIAMS, E. M., and YOUNG, F. J. 621.3(076)

Electrical engineering problems*

New York and London: McGraw-Hill, 1960. pp. xiv, 294. 23 × 15cm. £3

Contains intermediate- to advanced-level laboratory problems on such subjects as linear and non-linear d.c. and a.c. circuits, electromechanical devices, transformers, magnetic-core switching circuits, and vacuum and semiconductor electronic circuits. The omission of a contents list and the absence of chapter titles are unfortunate. Reviewed in the May 1961 *Journal*, p. 320.

OTHER PUBLICATIONS

AUSSCHUSS FÜR FUNKORTUNG

Accuracy and range of radio navigation systems: international discussion meeting, Munich, 25th and 26th April 1960

Düsseldorf: Ausschuss für Funkortung, 1960. pp. 269. 29 × 21cm. n.p.

BRITISH TRANSPORT COMMISSION

British Railways electrification conference, London, 1960: railway electrification at industrial frequency. Proceedings

London: British Transport Commission, 1961. pp. 496. 24·5 × 20·5cm. £5

CHERRY, E. C. (*Editor*)

Information theory: papers read at the 4th London symposium on information theory held at the Royal Institution, Aug. 29th to Sept. 2nd 1960

Butterworths, 1961. pp. xi, 476. 24·5 × 15·5cm. £4 15s.

Reviewed on p. 755.

COLONIAL OFFICE

Sound and television broadcasting in the overseas territories: handbook 1961

London: Colonial Office, 1961. pp. ii, 160. 33 × 20·5cm. n.p.

ELECTRICITY COUNCIL

A domestic-heating survey of England and Wales. Utilisation research report 18

London: Electricity Council, 1961. pp. 17. 28 × 21·5cm. n.p.

INTER-DEPARTMENTAL COMMITTEE ON BATTERIES

Second international symposium on batteries, 18th–20th Oct., 1960. Proceedings

Christchurch, Hants: Signals Research and Development Establishment, 1961. pp. 250. 28 × 21·5cm. £4

INTERNATIONAL FEDERATION OF AUTOMATIC CONTROL

Automatic and remote control: proceedings of the first international congress, Moscow, 1960. 4 vols.

Butterworths, 1961. 28 × 22cm. £45

STANDARDS ASSOCIATION OF AUSTRALIA

Australian standard rules for the electrical equipment of buildings, structures and premises. Part I—Wiring methods. 5th edition

Sydney: Standards Association of Australia, 1961. pp. 320. 21·5 × 14cm. £1 4s.

UNITED NATIONS

ECONOMIC COMMISSION FOR EUROPE

The situation and prospects of Europe's electric power supply industry in 1959/60

Geneva: United Nations, 1961. pp. 122. 28 × 21·5cm. n.p.

The state of rural electrification in Europe in 1959

Geneva: United Nations, 1961. pp. 71. 28 × 21·5cm. n.p.

VERBAND DEUTSCHER ELEKTROTECHNIKER

Microwave tubes: record of the international congress, Munich, 7–11 June 1960

Braunschweig: Friedr. Vieweg und Sohn, 1961. pp. xi, 608. 29·5 × 21·5cm. DM210

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a summary appeared in the *Journal* under 'The Journal digest: papers to be read', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card, which is available on request from the Secretary of The Institution

December 1961

E **18** *Monday* F. J. D. TAYLOR, O.B.E., B.SC.(ENG.). Lecture on 'Large steerable microwave aerials for communication with artificial Earth-satellites and space probes'†

M **19** *Tuesday* K. G. KING, D.F.H. Lecture on 'The use of controllable semiconductor rectifiers in machine control'†

E **20** *Wednesday* R. L. F. BOYD, PH.D., B.SC.(ENG.). Lecture on 'Satellite instrumentation'†

January 1962

O **4** *Thursday* F. J. LANE, O.B.E., M.SC. Fourth Hunter Memorial Lecture on 'The transmission of power at high voltages'‡

MED **5** *Friday* H. DAVSON, D.SC., will open a discussion on 'Membranes'* (at 6 p.m., tea at 5.30 p.m.)

M **9** *Tuesday* P. C. F. WOLFENDALE. Lecture on 'A linear transducer of high accuracy'†

E **10** *Wednesday* G. F. NEWELL *and* W. K. E. GEDDES, M.A. 'Tests of three systems of bandwidth compression of television signals' (paper 3631E) *synopsis:* July 1961

U **11** *Thursday* G. O. WATSON will open a discussion on 'The fourth edition of the regulations for the electrical equipment of ships'†

U **12** *Friday* Section Dinner-Dance (at the Café Royal, London, at 7 for 7.30 p.m.)

ED **16** *Tuesday* PROF. M. G. SAY, PH.D., M.SC., F.R.S.E., will open a discussion on 'Electrical engineering education in the Soviet Union'* (at 6 p.m., tea at 5.30 p.m.)

EM **17–18** *Wednesday–Thursday* (under the aegis of the British Conference on Automation and Computation) Symposium on electronic aids to banking (all wishing to attend are required to register; forms available on application to the Secretary of The Institution) (see p. 726)

I **22** *Monday* J. C. BAILEY *and* T. L. RICHARDS, B.SC.(ENG.), will open a discussion on 'Aluminium or copper conductors?'§ (see p. 778)

M **23** *Tuesday* P. F. GUNNING. Lecture on 'Power-supply control systems'†

S **24** *Wednesday* H. EDELS, B.SC.TECH., PH.D. Lecture on 'Arc theory and circuit-breaking'†

29 *Monday* I.E.E. and R.Ae.S. London Joint Group. P. HEARNE, H. FUCHS, B.SC., PH.D., *and* A. H. STEWART will open a discussion on 'Automatic maintenance testing'† (at the Royal Aeronautical Society, 4 Hamilton Place, London W.1, at 6 p.m., tea at 5.30 p.m.)

E **31** *Wednesday* E. B. B. CALLICK, B.SC., *and* J. C. FIRMIN, PH.D. Lecture on 'Storage tubes'†

* No advance information will be available, and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available
§ An abstract will be available in advance, but no Press report will be permitted

Elections and transfers

The following elections and transfers approved by the Council of The Institution are effective from the 2nd November 1961

ELECTIONS: 1st LIST

Graduates

DAVIES, Michael Henry, B.A.
FORDE, Patrick Columba, B.E.
GILHAM, Maurice Peter
GRAHAM, James
LEVENE, Bryan Charles, B.A.
McAULAY, Alastair Duncan, B.A.
MUNDY, Roy Alan
PHILLIPS, Malcolm John, B.SC.(ENG.)
PYNDIAH, Kristna Swami
SANDI, Wajan, B.E.
SHANMUGANATHAN, Murugesu
SMITH, Brian William, B.E.
VAUSE, John Edward, B.SC.
WENMAN, Graham John, B.SC.
WILSON, Oliver Bruce, B.E.
WITHERS, Michael John, DIP.TECH.(ENG.)

Students

FROST, Gerald William
HAMPTON, Alan Ambrose
HILL, Sidney Robert, B.SC.
LEWIS, Robert William
RAHMAN, Syed Fazl-I, B.SC.(ENG.)
WILLIAMSON, Ian Malcolm Herbert

TRANSFERS: 1st LIST

Student to Graduate

BRETT, Richard Gordon, B.SC.(ENG.)
CARE, John Michael, B.SC.(ENG.)
CARELESS, John Walter
COLLINS, Gerald, B.SC.(ENG.)
CRANE, Robert, B.SC.(ENG.)
CULLINGFORD, Michael Charles, B.SC.
DAVIES, Anthony Christopher, B.SC.(ENG.)
DEL MAR, John Morland, B.SC.(ENG.)
DENTON, Anthony Jon
DUBEY, Vishnu Deo
GIBB, Alan Neil, B.E.
HOSKYNS, Richard Francis, B.SC.(ENG.)
JONES, Peter David
LIMMER, Robert John
NATUSCH, Ian Henry, B.SC.(ENG.)
NORRIS, David Walter, B.SC.(ENG.)
O'BRIEN, Terence, B.SC.(ENG.)
PHILLIPS, Brian Harry, B.SC.(ENG.)
PITCHER, Roy Arthur
QUEK, Peck Moh, B.SC.(ENG.)
RIPPIN, Peter Joseph
ROBINSON, Peter Beresford
ROBSON, John, DIP.TECH.(ENG.)
ROWBOTHAM, Antony John Rigby, B.SC.(ENG.)
STEVENS, Michael James, B.SC.(ENG.)
YEO, Sebastian, B.E.
YOUNG, Richard David, B.SC.TECH.

ELECTIONS: 2nd LIST

Graduates

AMADO-TAYLOR, Cecil Balogun
APPS, David John, DIP.TECH.(ENG.)
BICKERSTAFFE, Ronald Stanley
BREWER, Joseph Hilton, B.SC.(ENG.)
BROWN, Colin Scrafton, B.SC.
CALVERT, John, B.SC.
CAUDLE, Brian Eric, B.SC.
CLYDE, Ronald Buchanan
CURRIE, Richard Michael, B.SC.
DINSDALE, Jack, B.A.
FUNG, Man Po, B.SC.(ENG.)
HADJIPASCHALIS, Andreas Joannou, B.ENG.
HALL, Frederick William
HOWLE, Selwyn, B.SC.(ENG.)
HUGHES, Kenneth Lawson, B.SC.
HUSSIN, Ibak Bin Abu
KASANJEE, Bhagwanjee, B.SC.(ENG.)
LATTER, Francis Christopher Russell
LAVERY, Joseph
LUCAS, Francis
McKILLIGAN, Ranald Scott, B.E.
MASON, Michael Geoffrey
MOORE, Peter Donald
NICOLAIDES, Anthony, B.SC.(ENG.)
PATTERSON, Stanley
PLUCK, Michael Richard, DIP.TECH.(ENG.)
ROGERS, Graham John, B.SC.(ENG.)
ROGERS, John Davis, DIP.TECH.(ENG.)
ROUGHLEY, Derek Peter
SPROUL, Malcolm Elder, B.E.
STONER, Michael David, B.SC.
TIA, Marc Roger Kiam, B.SC.
TILBURY, John Laurence, B.SC.
VILJOEN, Hendrik Christo, B.SC., B.ING.
WALKER, David, B.SC.
WALKER, Lt. William John, B.A., R.N.
WONG, Wai Cheong, B.SC.(ENG.)
WOOLLEY, Capt. Patrick John Wootton, B.SC.(ENG.), R.E.M.E.

Students

BARON, Paul Stuart
BERRY, David Walter Harold, B.E.
BHANGOO, Ranjit Singh
BOARDMAN, Michael Anthony
BREINGAN, William John Malcolm
BROWN, Derek
BURTON, Alfred William
CORDNER, Alan
CROOK, Anthony David James
DESAI, Shailesh Thakorlal, B.E.
FLEET, Roy Frederick
GAJANAYAKE, Jayasiri Patrick
GILLESPIE, Thomas Jarlath
GREAVES, Geoffrey Stuart, B.SC.
HENDERSON, Colin
HICKS, Christopher Edwin
HOCKLEY, David Henry
HUGHES, Brian Anthony
MOFFAT, Alastair McLean
MORRIS, Terence Douglas
MORROW, George Campbell
PARSONS, James Bryan
PULLEN, Ernest
RODGER, Douglas Ian
ROGER, Ian Morton
SCOTT, Graham Norman
STUDDART, Henry Martin
TINDALL, Colin Edward
VARDON, Harold Sydney
WILLIAMS, Ernest
WOODBURN, Derek Ronald

TRANSFERS: 2nd LIST

Student to Graduate

ADILOGLOU, Mahmout Izzet, B.SC.
BANFORD, Richard William
BEARDSHALL, Geoffrey Herbert
BIRCH, Robin Campbell
BLAKE, Alan Ronald, B.SC.(ENG.)
BOND, Robert Frank, B.SC.(ENG.)
BORMAN, John Brian, B.SC.(ENG.)
BRADLEY, David Alan, B.SC.
BRION, Stanley Albert, B.SC.(ENG.)
BYRON, John Raymond, B.SC.(ENG.)
CHOPRA, Jitinder Singh, B.SC., B.ENG.
CLEWS, Brian Leslie John, B.SC.(ENG.)

Student to Graduate (continued)

COOKE, Norman
COOKSON, Alan Howard, B.SC.(ENG.)
CORBETT, Aubrey Edward, B.SC.
CRAEN, John David Benedict, B.SC.(ENG.)
CREASEY, David John, B.SC.(ENG.)
DENNEY, Michael Robert, B.SC.(ENG.)
EDWARDS, John Charles, B.SC.
FAIRBANK, Richard, B.SC.TECH.
FERNANDO, Chandra Eric, B.SC.(ENG.)
GOLDSPINK, George Frederick, B.SC.(ENG.)
HANNA, Robert Noel
HARRISON, Kenneth Jeffrey, B.SC.
HULL, Sub-Lt. Peter Reynold, R.N.
IVES, Lesley Veronica
JALALUDDIN, Abdul Rahim
KING, Philip William, DIP.TECH.ENG.
LAWES, Ronald Albert, B.SC.(ENG.)
LAWRENCE, Gerald Norman, B.SC.(ENG.)
LEE, Royston George, B.SC.(ENG.)
LORD, William, B.SC.
LYNCH-WATSON, David, B.SC.
McCALLUM, Roylyn Muir
McCORMICK, Ian Patrick
MACDONALD, John Burnet
MAHANTI, Shailendra, D.F.H.
MEACHER, Edward Charles
MICHAEL, Peter Colin, B.SC.(ENG.)
MOORE, David William, B.SC.(ENG.)
PALEY, Robert
PALMER, Brian William
PARKER, John William
PARKHILL, Robert Colin, B.SC.
PLAYFORD, Christopher John, B.SC.TECH.
RATTRAY, William Gilbert, B.SC.
ROSKILLY, David Stewart, DIP.TECH.(ENG.)
SELWOOD, John William, B.SC.
SLADEN, Douglas Kevin, B.SC.
SMYTH, Patrick Noel
STEGER-LEWIS, Beverley Feargus David, B.SC.(ENG.)
WADE, James, B.ENG.
WEBB, Harold George, B.SC.TECH.

District Meetings

ARRANGEMENTS for District Meetings in January 1962 other than in the area of a local Centre

January 1962

OXFORD (at the Demonstration Room, Southern Electricity Board, 37 George Street, at 7 p.m.)

10 *Wednesday* W. J. BRAY, M.SC. 'Satellite communications'

READING (at the George Hotel, King Street, at 7.15 p.m.)

15 *Monday* R. J. HALSEY, B.SC.(ENG.), F.C.G.I., D.I.C. Electronics and Communications Section Chairman's Address 'Global communication'

British Nuclear Energy Society

THE British Nuclear Energy Society will be established on the 1st January 1962 in succession to the British Nuclear Energy Conference. Details of the B.N.E.S. were given in the October 1961 *Journal*, p. 638. Arrangements for four forthcoming meetings are given below

1962

JANUARY 8–12 *Monday* (10 a.m.)–*Friday*

Sponsoring society: The Institution of Mechanical Engineers
Place of meeting: Lecture Hall, Central Hall, London S.W.1

INTERNATIONAL HEAT TRANSFER CONFERENCE. This is a continuation of a conference held in Boulder, Colorado, U.S.A., from the 28th August to 1st September 1961. Registration will be required and should be made through The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1 (see September 1961 *Journal*, p. 582)

JANUARY 17 *Wednesday* (6 p.m.)

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

FIRST STEPS TOWARDS THE CLASSICAL NUCLEAR POWER STATION
J. P. Roux and C. Bienvenu

JANUARY 23 *Tuesday* (5.30 p.m.)

Sponsoring society: Joint Panel on Nuclear Marine Propulsion
Place of meeting: 76 Mark Lane, London E.C.3

INITIAL PROBLEMS OF THE SUBMARINE PRESSURIZED WATER REACTOR DESIGN AND THE RELATED EXPERIMENTAL PROGRAMME Prof. J. Edwards

JANUARY 31 *Wednesday* (5.30 p.m.)

Place of meeting: The Institution of Civil Engineers, Great George Street, London S.W.1

PLUTONIUM FUEL FOR NUCLEAR POWER L. Grainger and A. N. McIntosh (This is the first meeting organized by the B.N.E.S. itself)

During the past decade, plutonium-fuel technology has been developed within the United Kingdom Atomic Energy Authority, and a range of production, fabrication and processing techniques are now in advanced stages of investigation. The technology covers a wide variety of plutonium fuels and takes account of their application in various reactor systems. The authors review the substantial progress that has been made in recent years towards the efficient use of plutonium as an economic and reliable source of heat for nuclear power stations.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 9TH NOVEMBER 1961

	no. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	943	9846	5	10
£2 to <£5	2405	6627	12	3
under £2	31773	16808	18	8
		£49148	19	9

APPOINTMENTS AND NOMINATIONS

THE Council of The Institution have made the following appointments and nominations:

B.S.I. Technical Committees WEE/1—Definitions and symbols for welding, and WEE/6—Arc welding equipment	Mr. C. H. Flurscheim, B.A., MEMBER
Joint Advisory Committee on Engineering Education	Mr. B. Donkin, B.A., VICE-PRESIDENT
Women's Engineering Society (Council)	Sir Willis Jackson, D.SC., D.ENG., LL.D., F.R.S., PAST-PRESIDENT
Great Britain–U.S.S.R. Association	Mr. B. L. Metcalf, B.SC.(ENG.), MEMBER

UNITED ENGINEERING CENTER

A CEREMONY of dedication of the United Engineering Center in New York took place on the 9th November 1961. Five American societies participated in joint action to build the Center, which is adjacent to the United Nations Building, as their joint premises. The five societies are: the American Society of Civil Engineers; the American Institute of Mining, Metallurgical, and Petroleum Engineers Inc.; the American Society of Mechanical Engineers; the American Institute of Electrical Engineers; and the American Institute of Chemical Engineers.

To mark the ceremony, messages of congratulation were sent by the British Minister of Science, Lord Hailsham, and by the Presidents of the three Institutions. The message from the President of our Institution, Mr. G. S. C. Lucas, addressed to Mr. Willis F. Thompson, the President of the United Engineering Trustees, was as follows:

'On the occasion of the dedication in New York of the United Engineering Center I send greetings and good wishes on behalf of the members of The Institution, its Council and myself for this admirable joint enterprise and express through you to all the participants my conviction that the engineering profession and the public which it serves will benefit from this evidence of unity and strength.'

INSTITUTION SUMMER MEETING, 1962

AT the invitation of the Chairman and Committee of the Mersey and North Wales Centre, a Summer Meeting of The Institution will be held in the area of the Centre from Monday evening, 18th June, to Friday evening, 22nd June 1962. Further details will be circulated with the January 1962 *Journal*.

COMPONENTS FOR MICROWAVE CIRCUITS

A CONFERENCE and associated scientific exhibition on components in microwave circuits will take place in London in September 1962. The conference is being organized by the Electronics and Communications Section of The Institution, who also arranged the conference on microwave measurement techniques held in September 1961, to which the 1962 conference will be a sequel.

Research and development in the microwave field progress so rapidly that from time to time the state of the art must be reviewed and the opportunity taken to present the result of recent work. A vitally important part of the field is formed by the components with which microwave devices may be constructed.

Within the last few years, an impressive amount of work has been done on extending the frequency range of microwave components; and new types—providing novel facilities—have come, and continue to come, to the fore. The results of this work will form the subject of the conference, which will include within its scope all forms of microwave component, as distinct from complete microwave circuits.

The Organizing Committee for the conference, under the chairmanship of Mr. F. J. D. Taylor, O.B.E., B.SC.(ENG.), MEMBER, hope that intending authors of contributions will submit as soon as possible, and preferably not later than the 15th February 1962, abstracts of not more than 250 words for preliminary consideration. Further information will be available in due course from the Secretary of The Institution.

THE CONFERENCE OF ENGINEERING SOCIETIES OF WESTERN EUROPE AND THE UNITED STATES OF AMERICA (EUSEC)

REPORT ON EDUCATION AND TRAINING OF PROFESSIONAL ENGINEERS

AT a meeting in New York in April 1958, EUSEC adopted a recommendation that a comprehensive report on the education and training of professional engineers in Western Europe and the United States of America should be prepared, and to that end established a Committee on Engineering Education and Training, to be assisted by two working parties—one in respect of the diagrams and glossary and the other to prepare a general report.

The first task of the committee was to appoint a national

reporter in each country concerned to obtain the necessary data and prepare a draft report. These national reports form the basis of the main EUSEC report, just published, which includes information in respect of the following countries represented in EUSEC—Austria, Belgium, Denmark, Finland, France, Western Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America—and of the following countries represented by O.E.E.C., but not in EUSEC—Greece, Iceland, Republic of Ireland, Luxembourg, and Turkey.

The report is published in three volumes. Vol. 1 gives an introduction and a description of the systems of engineering education in the 19 countries named above, including elementary and secondary education before entry to engineering schools. Vol. 2 is a comparative study of engineering education and training in the countries concerned. Vol. 3 contains a glossary of terms used in engineering education and training in these countries.

The volumes provide a general guide to the form of engineering education in America and Western Europe. They are factual; and, although they do not attempt to comment on the value of one type of engineering education as compared with another, they are sufficiently comprehensive to provide the engineer or educationalist with useful background knowledge of the different systems of engineering education in the countries concerned.

The publication of the report has been made possible, in large measure, by generous financial assistance received from the Ford Foundation and the Organisation for European Economic Co-operation. The report (price £1 5s.) may be obtained from the Secretary, The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1. A review of the report will be published in a forthcoming issue of the *Journal*.

SECOND SYMPOSIUM ON ELECTRONIC-EQUIPMENT RELIABILITY

THE Electronics and Communications and Measurement and Control Sections of The Institution are arranging for a second symposium on electronic-equipment reliability to take place in October 1962. A leaflet giving details of the symposium is being sent with this issue of the *Journal* to each member of the two Sections. Anyone else may obtain a copy of the leaflet on application to the Secretary of The Institution.

THE FIRST SEVEN GRAHAM CLARK LECTURES

THE Graham Clark Lectures have been presented annually in turn by the three major Institutions since 1955. It has been felt that many members would welcome an opportunity to possess a set of these lectures collected into one cover. Consequently, they have been republished as a book that includes the first seven in the form in which they appeared in the *Journal*.

'The First Seven Graham Clark Lectures' may be obtained by application to the Secretary of The Institution, price 10s., post-free.

THE INSTITUTION EXAMINATION

THE dates of the next Institution Examination are: Part I, 9th–11th April; Part II, 5th–6th April; and Part III, 28th May–1st June 1962. The closing date for the receipt of entries for Parts I and II is the 15th February (home entries) and for Part III the 15th March 1962 (home entries).

The Board of Examiners is as follows:

C. T. Baldwin, M.A., MEMBER
H. Billet, B.SC.(ENG.)
Prof. F. Brailsford, PH.D., B.SC.(ENG.), MEMBER
W. J. Bray, M.SC.(ENG.), MEMBER
J. Brown, M.A., PH.D., D.SC.(ENG.), ASSOCIATE MEMBER
H. Buckingham, PH.D., M.SC.(ENG.), ASSOCIATE MEMBER
R. Cheesewright, B.E.
H. M. Clarke, T.D., M.SC., MEMBER
A. Draper, M.B.E., B.SC.(ENG.), MEMBER
W. Fraser, M.SC.(ENG.), MEMBER
G. F. Freeman, M.SC.(ENG.), MEMBER
Prof. M. R. Gavin, M.B.E., M.A., D.SC., MEMBER
W. J. Gibbs, D.SC., MEMBER
A W. Gillies, B.SC., PH.D., F.INST.P.
D. S. Gordon, B.SC., PH.D., ASSOCIATE MEMBER
Prof. J. Greig, M.SC., PH.D., MEMBER
J. G. Henderson, B.SC., ASSOCIATE MEMBER
H. C. Mann, B.SC.(ENG.), MEMBER
W. D. Oliphant, B.SC., F.R.S.E., MEMBER
Prof. J. E. Parton, PH.D., B.SC., MEMBER
Prof. M. G. Say, M.SC., PH.D., F.R.S.E., MEMBER
F. Scowen, ASSOCIATE MEMBER
G. D. Sims, M.SC., B.SC., PH.D., ASSOCIATE MEMBER
P. F. Soper, PH.D.(ENG.), B.SC.(ENG.), MEMBER
E. O. Taylor, B.SC., MEMBER
J. W. T. Walsh, O.B.E., D.SC., M.A., MEMBER
Prof. Emrys Williams, B.ENG., PH.D., MEMBER

JOURNAL AND *PROCEEDINGS*

OUT-OF-PRINT NUMBERS

THE Secretary of The Institution would be glad to receive copies of the following issues of the *Journal* and the *Proceedings*. Members are invited to return their copies to him in order that the gaps in the stock of back numbers can be filled. Payment will be made at the rate of 5s. for each copy returned in good condition, plus postage.

Journal (new series)	*Proceedings*
Vol. 2, nos. 13, 18 (1956)	Part A, vol. 102, nos. 1, 2 (1955)
„ 3, „ 31, 35 (1957)	„ „, „ 103, no. 7 (1956)
„ 4, „ 43, 44, 45 (1958)	Part B, „ 102, nos. 1, 2 (1955)
„ 5, „ 56, 57, 58 (1959)	„ „, „ 103, no. 7 (1956)
„ 6, „ 61, 62, 64, 68, 69 (1960)	„ „, „ 105, no. 21 (1958)

SUPPLEMENT TO CATALOGUE OF THE LENDING LIBRARY

THE last edition of the catalogue of the Lending Library, published in 1959, lists under both author and subject all books acquired to the end of July 1959. A supplement is now available, listing over 200 books added to the Library between August 1959 and July 1961. The price of this supplement is 1s. post-free. It is supplied without charge to purchasers of the catalogue, copies of which are still available, price 3s. 6d. post-free.

SUBSCRIPTIONS TO THE PUBLICATIONS OF OTHER ENGINEERING INSTITUTIONS

MEMBERS are reminded of the reciprocal arrangements whereby they can obtain the technical periodicals of other engineering institutions and societies at the specially reduced rates listed below:

	£	s.	d.
Institution of Civil Engineers:			
Proceedings (single issues 3s. 6d.)	2	0	0
Institution of Mechanical Engineers:			
Chartered Mechanical Engineer	2	2	6
Chartered Mechanical Engineer and separates of *Proceedings* and Automobile Division *Proceedings*	7	5	6
Chartered Mechanical Engineer and separates and bound volumes of *Proceedings* and Automobile Division *Proceedings*	10	4	6
Chartered Mechanical Engineer and bound volumes of *Proceedings* and Automobile Division *Proceedings*	8	18	6
Bound volumes only of Institution *Proceedings* and Automobile Division *Proceedings*	7	5	0
Self-binding case for the copies of *Chartered Mechanical Engineer*		13	0
American Institute of Electrical Engineers:			
Electrical Engineering	2	10	0
Transactions	4	17	6
Communication and Electronics	2	2	0
Application and Industry	2	2	0
Power Apparatus Systems	2	2	0
Associazione Elettrotecnica Italiana:			
L'Elettrotecnica	2	18	0
Alta Frequenza	2	2	0
Dansk Ingeniørforening:			
Ingeniøren	1	5	0
Engineering Institute of Canada:			
The Engineering Journal	1	9	0
Institution of Engineers, India:			
Journal			
Civil engineering division		14	0
Mechanical engineering division		14	0
Electrical engineering division		14	0
Electronics and telecommunication engineering division		7	0
Chemical engineering division		7	0
Mining and metallurgy division		7	0
General engineering division		7	0
Institute of Physics and the Physical Society:			
British Journal of Applied Physics	3	0	0
Journal of Scientific Instruments	3	0	0
Both the above publications	6	0	0
Institute of Radio Engineers, America:			
Proceedings	4	17	6
Transactions of the 21 Professional Groups	35	16	6
Transactions of any single Professional Group	3	1	0
Institution of Engineers, Australia:			
Journal	3	3	0
Civil Engineering Transactions	1	4	0
Electrical and Mechanical Engineering Transactions	1	4	0
Both parts	2	8	0
Koninklijk Instituut van Ingenieurs:			
De Ingenieur	2	5	0
New Zealand Institution of Engineers:			
New Zealand Engineering	1	17	6
Société Belge des Électriciens:			
Bulletin	1	7	6
Société Française des Électriciens:			
Bulletin	3	15	0
South African Institute of Electrical Engineers:			
Transactions	3	0	0
Svenska Teknologföreningen:			
Teknisk Tidskrift	4	0	0
Verband Deutscher Elektrotechniker e.V.:			
Elektrotechnische Zeitschrift edition A (*ETZ-A*)	3	4	6
Elektrotechnische Zeitschrift edition B (*ETZ-B*)	2	4	6
Elektrotechnische Zeitschrift editions A and B	5	4	0
Nachrichtentechnische Zeitschrift (*NTZ*)	2	14	0

Members' subscriptions must be transmitted through the Secretary of The Institution of Electrical Engineers, except those for the publications of The Institution of Mechanical Engineers, which should be sent to the Secretary of that Institution, and those for the *Proceedings* of The Institution of Civil Engineers, which should be sent to one of the following agents:

Sir Isaac Pitman and Sons Ltd.: The Book Centre, North Circular Road, Neasden, London N.W.10; Little Collins Street, Melbourne, Australia; Pitman House, 381–3 Church Street, Toronto, Canada; and 27 Becketts Buildings, President Street, Johannesburg, South Africa. Pitman Publishing Corporation, 2 West 45th Street, New York. A. H. Wheeler and Co.: Hornby Road, Bombay; 11 Clive Street, Calcutta; and 115 Elgin Road, Allahabad.

STUDENTS' QUARTERLY JOURNAL

AN article on peat in Ireland, entitled 'The new fuel', by K. G. Egar, is a principal feature of the December 1961 issue of the *Students' Quarterly Journal*. There is also an amusing article on 'Encounters in training' by B. R. Parsons. Other subjects discussed in the issue are millimetre waves (J. Allison), a radio survey system (G. M. Willdey), a comparison of transistors and valves (A. W. Hart), operating mechanisms for medium-voltage switchgear (A. Charlton), stereo in sight and sound (J. Watson), spark-gaps and high-voltage measurements (E. C. Salthouse), and the slide rule (R. H. Ogborn).

Further items include Section reports, a note on engineering in the Civil Service, readers' letters, and book reviews.

Announcements to members (continued)

RETIRED MEMBERS

MEMBERS are reminded of a rule, which has been in existence for some years, that enables Corporate members and Associates who have retired from the profession and are still desirous of retaining their membership of The Institution to do so without payment of further subscriptions, or at a reduced subscription, depending on their length of membership. It is left to the members concerned to make application to be brought within the rule. The rule, which does not apply retrospectively, is set out below:

Any Corporate member or Associate who has reached the age of 60 and has retired from the practice of his profession or business may apply to the Council of The Institution to waive or reduce his future annual subscription, depending on the length of his continuous membership as follows:

25 years	full remission
20–24 years	two-thirds reduction
15–19 years	one-third reduction.

If a retired member of 25 years' standing desires to continue to receive the *Journal*, he can do so on payment of 10s. per annum. Parts A, B and C of the *Proceedings* will also be available to him at the appropriate subscription rates.

MEMBERS OF LONG STANDING

THE attention of members is called to a rule that provides that a member of any class who has completed 50 years of membership of The Institution is not required to pay any further membership subscriptions, regardless of whether he is still in remunerative employment. This rule operates automatically, and the member on qualifying is notified accordingly. If he desires to receive the *Journal* or the *Proceedings*, the arrangement for retired members of 25 years' standing applies (see above).

GENERATION OF ELECTRICITY BY UNCONVENTIONAL METHODS

AT a meeting on the 14th February 1962 of The Institution of Mechanical Engineers, in conjunction with the Thermodynamics and Fluid Mechanics Group, a paper 'Generation of electricity by unconventional methods' by H. Billett, P. D. Dunn and H. Whitby of University College London will be read and discussed.

The meeting will be held at 1 Birdcage Walk, London S.W.1, and members of our Institution are invited to attend.

COMMUNICATIONS

WITHOUT writing a formal paper an author may be able to submit to The Institution a communication that, by dealing with practical problems encountered in the development, manufacture, operation or maintenance of electrical equipment, or with limited aspects of a wide subject, would be of considerable interest to the readers of the *Proceedings*. Equally welcome is the brief announcement of a development that may later become the subject of a paper. A suitable length for a communication is 300–3000 words, together with a few illustrations.

The author of a communication may offer it, instead, for publication in the *Journal* as a letter to the Editor, and if it is acceptable and of sufficiently general interest it will be published in this way. As a rule, a letter should not exceed about 300 words, but a maximum of 1000 words can be accommodated in special circumstances.

NON-DESTRUCTIVE TESTING

THE 4th international conference on non-destructive testing will be held in London from the 9th to 13th September 1963. It will be organized by The Institution of Mechanical Engineers and sponsored by the British National Committee for Non-Destructive Testing. The conference will cover basic physics and the selection of method; non-destructive testing in general structures and in transport; and future needs.

Prospective authors and others may obtain further information from the Secretary of The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1.

1962 ANNUAL EXHIBITION OF THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

THE annual exhibition of The Institute of Physics and The Physical Society will be held in the Old and New Halls of the Royal Horticultural Society, Vincent Square, London S.W.1, from the 15th to 19th January 1962. In the lecture room above the New Hall, Dr. C. A. Taylor will talk on 'A physicist looks at music' at 5.45 p.m. on the 16th January, and at the same time on the 18th January Prof. R. V. Jones will speak on 'The uses of elasticity in instrument design'.

Admission to the exhibition will be by ticket only.

DIAMOND JUBILEE OF TRANSATLANTIC WIRELESS

THE 12th December 1961 was the 60th anniversary of Marconi's transmission of the first wireless signal across the Atlantic. On that day, at Signal Hill, Newfoundland, overlooking St. John's harbour, Marconi and his assistant, G. S. Kemp, using one of the primitive receivers of the period with a telephone earpiece, heard a faint succession of Morse S's sent from Poldhu, Cornwall.

The transmitter at Poldhu, designed by Prof. J. A. (later Sir Ambrose) Fleming, was supplied by an oil-engine-driven 2000V 50c/s alternator. It used two 20kW transformers parallel-connected to give an input voltage of 20000V. This was fed through r.f. chokes to a closed oscillatory circuit in which a capacitor discharged across a spark-gap via the primary of an r.f. transformer. The secondary of this transformer was connected to a second spark-gap and capacitor and the primary of a second r.f. transformer whose secondary winding was in series with the aerial. Keying was effected by short-circuiting the chokes in the alternator output. The aerial system at Poldhu consisted of 54 copper wires arranged in a fan-shape and upheld by a triatic slung between two 150ft masts.

At Signal Hill, a kite carried the receiving aerial to a height of 400ft. Marconi used an untuned receiver with a

telephone earpiece in series with a coherer. At 12.30 p.m., Newfoundland time, on the 12th December 1901, he heard, faintly but distinctly, the groups of three dots that could only have been emanating from Poldhu, 2200 miles away.

To mark the diamond jubilee of transatlantic wireless, the Science Museum, South Kensington, London S.W.7, opened a small special exhibition on the 13th December 1961. It will continue until the 25th January 1962. The museum is open to the public from 10 a.m. to 6 p.m. on weekdays and from 2.30 to 6 p.m. on Sundays. It will be closed on Christmas Day.

AIR MINISTRY DIRECTORATE OF WORKS EXHIBITION

THE Air Ministry Directorate General of Works (A.M.W.D.) are holding an exhibition in the Air Ministry Whitehall Building, London, from the 9th to 13th January 1962. It will be open each day from 10 a.m. to 5.30 p.m., and admission will be free.

The A.M.W.D. are responsible for the design, construction, operation and maintenance of works services at all Royal Air Force stations at home and oversea, and at Ministry of Aviation airfields, including London Airport. The work of the mechanical and electrical engineering division of the A.M.W.D. will be illustrated at the exhibition by items of equipment, models, photographs and cine films. Equipment exhibits will include instruments and control and alarm apparatus, Diesel-engine generating sets, airfield lighting equipment, and switchgear and electrical-distribution plant.

SHRIVENHAM SCHOLARSHIPS

FIFTEEN civilian scholarships are being offered at the Royal Military College of Science, Shrivenham. Successful candidates take courses, normally of three years' duration, for the London University degree of B.Sc.(Special) in chemistry, physics or mathematics or B.Sc.(Eng.). Those to whom awards are made are expected to join the Civil Service when they have taken their degree.

A scholarship carries exemption from payment of tuition and examination fees, and the student receives a maintenance allowance of £338 a year. No means test is imposed, and the allowances are not liable to income-tax. Candidates must be under 22 on the 1st October of the year of entry, unless they have completed their National Service, when they must be under 24.

Application forms and further information may be obtained from the Registrar, Royal Military College of Science, Shrivenham, nr. Swindon, Wilts.

INFORMATION THEORY

AN international symposium on information theory will be held in Brussels from the 3rd to 7th September 1962 and will be organized jointly by the Benelux Section of the Institute of Radio Engineers and the Belgian Society of Telecommunication and Electronics Engineers (S.I.T.E.L.), with the co-operation of the Université Libre de Bruxelles.

Further information may be obtained from the chairman of the organizing committee, Dr. F. L. Stumpers, Philips Research Laboratories, Eindhoven, Netherlands.

ENGINEERING ASPECTS OF MAGNETOHYDRODYNAMICS

A SYMPOSIUM on the engineering aspects of magnetohydrodynamics will be held at the University of Rochester, Rochester, N.Y., on the 28th–29th March 1962. The meeting, which is being sponsored by the American Institute of Electrical Engineers, the Institute of the Aeronautical Sciences, the Institute of Radio Engineers, and the University of Rochester, will be concerned with plasmas in the presence of a magnetic field and, in particular, with their engineering aspects. Four sessions will cover communications and diagnostics, flight applications, fusion, and power conversion.

Further information can be obtained from Mr. G. W. Sutton, Chairman of the Programme Committee, Massachusetts Institute of Technology, Room 3–254, Cambridge 39, Mass., U.S.A.

OVERSEA ATTENDANCE REGISTER

DURING the period 17th October to 16th November 1961, these members called at the Institution building and signed the Attendance Register of Oversea Members:

ARNOT, R. S. (Kitwe, N. Rhodesia)
BRAND, H. R. (Kingston, Jamaica)
CLISBY, R. L. (Henley Beach, S. Australia)
CULLITY, M. J. (Perth, W. Australia)
HAMPTON, J. D. (Lindfield, New South Wales)
JAYAWEERA, V. H. A. (Dehiwela, Ceylon)
KESKAR, P. V. (Bombay)
LANG, H. G. (Blair Athol, S. Australia)
MURRAY, C. C. (Nairobi, Kenya)
SCOTT, R. L. B. (Campbellford, Ontario)
SMITH, E. A. (Santiago, Chile)
TRUSS, H. W. (New York)
VOHRA, S. P. (New Delhi)
WADE-COOPER, F. (Calcutta)
WILSON, J. (Sydney)

THE MAUNDER–HOWE PRIZE IN ELECTRICAL ENGINEERING

THE Council of King's College, Newcastle upon Tyne, was recently informed that the late Prof. G. W. O. Howe, MEMBER, a graduate of the college, had bequeathed a fixed part of the residue of his estate to endow an undergraduate prize in electrical engineering, to be known as the Maunder–Howe Prize, in memory of his wife, who was also a former student of the college.

The prize will have an annual value of about £45 and will be awarded on the recommendation of the head of the Department of Electrical Engineering, King's College, for a distinguished performance in the final year of the degree course. In any year in which no one is considered to be of outstanding ability the prize will not be awarded, and there is provision for dividing it should two or more students of equal or comparable merit present themselves.

NEW I.C.E. LECTURE THEATRE

THE modernized lecture theatre at The Institution of Civil Engineers, London, containing new lighting and seating arrangements, was brought into use on the 7th November 1961. There are 284 tip-up seats, and the floor from the centre of the theatre to the rear has been raked.

All types of slide can be shown on a projector equipped with the latest xenon lighting. A 16mm-film projector can take both optical and magnetic sound tracks. The speaker can explain points on an electrical blackboard.

For overflow audiences, the lecture theatre is connected by closed-circuit television to the Great Hall and the Brunel Room.

News from the Centres

WEST WALES (SWANSEA) SUB-CENTRE

Annual General Meeting

When Mr. J. Nelsey, Chairman of the Sub-Centre, presided at the Annual General Meeting on the 26th September 1961, he gave an interesting report on the technical and social activities of the Sub-Centre during the past year. The meeting was held in the Assembly Hall of the Velindre Works of the Steel Company of Wales, and everyone present was interested to learn from him of the full programme that had been accomplished during the year.

Past activities

In the course of his report he touched on the membership of the Sub-Centre; the meetings of the Committee; the attendance of members and visitors at Ordinary Meetings; the Faraday Lecture delivered in Swansea; the Dinner-Dance attended by distinguished visitors; and the proposed three new Divisions in the structure of The Institution covering respectively Electronics, Power, and Science and General. His report was received with acclamation, and he then presented a bound copy of 'The Rubá'iyát of Omar Khayyám' to Mr. J. Harley to mark the Sub-Centre's appreciation of his Chairmanship of the Sub-Centre during the 1959–60 Session. After Mr. Harley had expressed his warm thanks for the gift he had received, an interesting discussion took place on the Chairman's report.

During the meeting Mr. J. Nelsey vacated the Chair in favour of Dr. W. E. Lewis, the new Chairman. Mr. Nelsey thanked the members and the Committee for their support during his year of office. In responding, Dr. Lewis thanked Mr. Nelsey on behalf of the members for the work he had done during the past year. Two coloured films were then shown, including one stressing the importance of safety.

Chairman's Address

At the meeting of the Sub-Centre held on the 12th October 1961, Dr. W. E. Lewis gave his Address 'The training of electrical engineers'. Before proceeding to do so he presented bound copies of 'The history of The Institution' to Mr. C. Evans and Mr. D. H. Hughes, both of whom had recently relinquished their offices respectively as Honorary Secretary and Assistant Honorary Secretary of the Sub-Centre. In making the presentation Dr. Lewis stated that both had given valuable service to the Sub-Centre over a number of years and that they were deserving of the warmest thanks of all members of the Sub-Centre.

Better opportunities

In a very informative and interesting Address, Dr. Lewis referred to the Crowther Report and the White Paper dealing with 'Better opportunities in technical education' (Cmnd. 1254). An article, 'A logical pattern for technical education', by Sir Willis Jackson appeared in the February 1961 *Journal*, p. 97. This summarized the White Paper proposals. A further article, 'Better opportunities in technical education', by Dr. F. T. Chapman appeared in the March 1961 *Journal*, p. 159, and covered the historical background of the White Paper.

Dr. Lewis gave an outline of the present courses undertaken by students for Ordinary and Higher National Certificates and referred to the disturbingly high proportion of students who did not complete their courses or failed to pass the examinations at the end of them. He thought that the new pattern of courses outlined in the White Paper for operatives, craftsmen and technicians would help many more students to succeed.

Autumn Visit

The Autumn Visit of the Sub-Centre took place on the 4th October 1961 when a party of 39 visited Milford Haven. Of the party, 26 visited an oil refinery and the remainder a beryllium factory. The journey to Milford Haven, an ancient harbour and 18th-century town, was accomplished by cars on a day of rains, squalls and floods. The party conducted round the factory were able to see the manufacture of special articles 'on the secret list'.

Oil refinery visited

The oil refinery was near the village of Herbrandston, some two miles from Milford Haven, and on rolling ground running down from a plateau to the deep water of the Haven where marine conditions are very suitable for the handling with safety of ocean tankers of up to 100000 tons deadweight, at almost any state of the tide. In the lay-out of the refinery, imaginative treatment was given with the aim of concealing the refinery from view and so detracting as little as possible from the beauty of the Pembrokeshire coastline.

At the marine terminal some 1000 yards from the shore could be seen the berths and the loading and discharge facilities whereby ships discharge their crude oil into storage tanks inland and take on cargoes of finished products from the refinery. In the refinery could be seen the storage tanks, process units comprising distillation plants and fractionating towers automatically controlled from a central control room, equipment for the air-cooling of refined products, and electric substations.

The visit to the refinery was well worth while. It is true that we saw a tanker at the marine terminal, but we saw little oil nor smelt any. Inside the refinery, we little realized that oil was flowing from tank to tank to various process plants through miles of pipelines. Perhaps some of the articles we buy tomorrow in our local shop will possess some chemical constituents of crude oil brought from Kuwait and Iraq to Milford Haven.

A. E.

NORTH-WESTERN CENTRE

Generation and transmission equipment

The North-Western Centre opened its 62nd Session with a crowded meeting on the 3rd October 1961, when the retiring Chairman, Mr. F. Linley, inducted his successor, Mr. C. H. Flurscheim, into the Chair. In his Chairman's Address, Mr. Flurscheim reviewed the progress in generation and transmission equipment over the last 12 years, taking as a starting-point Sir Cecil Dannatt's Chairman's Address to the Centre in 1949, in which he suggested possible lines of development.

In the intervening period, the demand in Britain had been more than doubled, and this ever-increasing demand had called for larger and more efficient turbine-generator plant and corresponding developments in transmission engineering.

Field of generation

In the field of generation, Mr. Flurscheim estimated that, in terms of 1961 money, the cost of electricity had halved every 25 years. This was largely due to more advanced steam conditions and to the increase in the size of sets, which had multiplied by ten times in 20 years, from 50 to 500 MW. These large sets were being designed for quick starting and stopping to permit base-load operation of nuclear plant.

In parallel with development of turbogenerator units had gone research into alternative methods of generation, such as the magnetohydrodynamic system, in which so far powers of about 200 kW had been obtained for periods of about 10 sec. Still further ahead was the possibility of direct generation from controlled fusion, but this demanded the production of temperatures of about 100 000 000° C.

Still another method of direct generation of electricity from heat was by means of the Edison effect, i.e. by electron emission from a heated cathode. One problem here was to reduce the space charge between the electrodes to permit the passage of large currents. Output voltages up to 3V had been obtained with cathode temperatures of 3000°–4000° C. Efficiencies of 17% had been claimed, and 30% appeared possible.

Methods based on heating bimetallic junctions did not offer efficiencies above 1%, but some semiconductors exhibited much higher thermoelectric voltages. Using tellurides of heavy metals, multi-stage generators of this class had been built with efficiencies of 12% with a temperature difference between the junctions of about 500° C.

A still further possibility was the fuel cell, but, in spite of efficiencies of 50–75% on small units of a few kilowatts, output, practical application to power generation appeared to be remote.

Progress in transmission

On the transmission side, the voltage in service had been raised to 500 kV, and projects up to 750 kV were under discussion. High-voltage direct current had become a practical possibility. In transformers there had been the introduction of cold-rolled steel, with the consequent developments in core design. The size of the individual units had also increased to 400 MVA, with 600 MVA 3-phase units under consideration.

The performance and breaking capacity of switchgear had been increased. Circuit-breakers for 275 kV, with a breaking capacity of 7500 MVA, had been in service in 1952, and circuit-breakers capable of breaking 35 GVA at 400 kV and carrying 3 GW per circuit were now being designed.

Mr. Flurscheim's Address was followed later in the month by the Addresses of the Chairmen of the specialized Groups.

H. G. B.

MERSEY AND NORTH WALES CENTRE

Electricity supply and Van de Graaff generator

On Monday, 2nd October 1961, at the Royal Institution, Liverpool, Mr. R. N. Pegg, Chairman, gave his Address 'For the record'. His theme was the development of electricity supply in the North Wales Sub-Area, of which he is manager, and he surveyed the co-ordination, consolidation and expansion that had taken place since vesting day.

Particle acceleration

The meeting on Monday, 16th October, was held in the Chadwick Laboratories of the University of Liverpool, when Mr. B. S. Halliday gave an informal lecture on the 12 MeV tandem Van de Graaff accelerator. Mr. Halliday traced the principle of the Van de Graaff generator and its application to particle acceleration and described the tandem machine, referring specially to the methods of double ionization and stripping. He reviewed the features of the university machine, including beam handling, magnetic-field stability and voltage stabilization.

A visit was made to inspect the machine. Installation of the machine had begun only nine weeks earlier, and trials had been made at 2·5 MeV. We were fortunate in seeing the internal assembly and also that the maker's installing engineer was available with Mr. Halliday to reply to questions.

Annual Dinner

The Annual Dinner on Monday, 6th November 1961, was held in the Grosvenor Hotel, Chester, and was favoured by the presence of Mr. O. W. Humphreys, a Vice-President of The Institution. Mr. R. N. Pegg presided. The toast of The Institution was proposed by Sir John Charles Nicholson, Senior Consultant-Surgeon to Bethnal Green, St. Leonard's and St. Matthew's Hospitals, London. Sir John claimed an almost neighbourly interest in The Institution, as he lives next door to the one-time home of the Society of Telegraph Engineers. He said that in his lifetime the progress of science and medicine had been wide and rapid. 'Where it will lead to I do not know. Perhaps medical science will improve so much that we may almost reach immortality and people may die only of boredom unless some half-educated maniac decides to blow us to pieces.'

Mr. O. W. Humphreys, responding, said that we in our Institution were feeling the wind of change, not only the outward and visible one in the Building but in our constitution—changes made after 2½ years of careful investigation. The new structure was aimed at the removal of rigidity.

At the Mersey and North Wales Centre Annual Dinner on the 6th November 1961

From left to right: Mr. D. A. Picken, Mr. O. W. Humphreys, Alderman Miss Beryl Neild, Sir John Nicholson and Mr. R. N. Pegg

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Deviation to 'power' or 'electronics' should be made only through the central channel of science. He said that meetings might be considered in two broad categories: those that provided a specialized discussion in detail and at which the quality and not the quantity of the contribution was the prime consideration, and those that followed the process of continuous education, whereby a lecturer in a specialized subject might present an outline picture of wide appeal to a non-specialist audience and a stimulus might be given to those capable of concentrated study and research.

The guests

The health of our guests was proposed gracefully and comprehensively by Mr. D. A. Picken.

Thanking The Institution on behalf of the guests, Alderman Miss Beryl Neild, the Mayor of Chester and Admiral of the Dee, proved a charming and delightful speaker. Miss Neild made reference to Chester's 200-year-old Royal Infirmary, quoting extracts from early records. Speaking as one of his consumers, she congratulated Mr. D. H. Kendon on his C.B.E.

Forthcoming events

The Annual Dinner-Dance has been arranged for Friday, 23rd March 1962, at Hulme Hall, Port Sunlight.

The Summer Meeting of The Institution will be held in the area of this Centre from the 18th to 22nd June 1962.

E. W. A.

WESTERN CENTRE

Chairman's Address

THE 1961–62 Session of the Centre opened on Monday, 9th October 1961, at Cardiff, when Mr. T. Gill delivered his Chairman's Address. He chose as his subject a review of the applications and advances made in the utilization of electrical energy during the past 25 years, with particular reference to the many industries that are associated with the southern part of Wales. The problems associated with rapid expansions of electrical demands were fully emphasized, and the exacting requirements of consumers were discussed in detail.

A challenge

The large audience had the pleasure of being able to appreciate more clearly the complexities with which the utilization engineer had had to battle over the period in question. Now, in the 1960s, the stimulus of new industries and more complex circuit techniques offered a fascinating challenge to the young electrical engineer embarking on a career in the utilization of electrical energy.

Jubilee

As many members of this Centre are aware, this session marks the 50th anniversary of the Centre, and, to celebrate this, a special dinner will be held on Monday, 5th March 1962. This will, of course, be additional to the Annual Dinner and Dance that will be held at Porthcawl during the session.

It is hoped that this anniversary will be marked by other arrangements of a more permanent nature, and, with this in mind, a sub-committee has been formed to explore other avenues. Full details will be published as they become available.

E. J. M.

NORTH MIDLAND CENTRE

Faith, hope and charity

IN his vote of thanks to Mr. W. Paterson, the retiring Utilization Group Chairman, Mr. A. R. Rumfit likened the 'New Year' of The Institution's activities to a faith. Certainly after listening to Mr. W. J. A. Painter reading his Inaugural Address as Centre Chairman, and Mr. F. Clark his Address as Utilization Group Chairman, the membership would have had implicit faith in the capabilities of these gentlemen to conduct the affairs of the Centre with dignity and efficiency.

The new session opened on the 3rd October 1961, when the retiring Chairman, Mr. F. W. Fletcher, asked Mr. Painter to give his Address to a gathering of 120 members and guests. With characteristic clarity, Mr. Painter dealt with the changing influences in the planning of the British Grid system, reviewing, as he did, the growth of the system since the Central Electricity Board was established in 1926. How these varying influences affected the planning was illustrated by examples of the Grid system in the North Eastern Region.

In proposing a vote of thanks to Mr. Painter, Prof. G. W. Carter commented on the lack of feminine members at a university-faculty gathering on the previous evening and the terse opinion of a Yugoslav student on this particular aspect. 'I like it', said the student; which was what Prof. Carter said of Mr. Painter's Address. It aptly summarized the opinion of the audience.

Mr. A. J. Coveney thanked the retiring Chairman, Mr. F. W. Fletcher, for his meticulous year of office.

Safety and economy

The 17th October saw the opening of the Utilization Group meeting, with Mr. F. Clark reading his Address 'Utilization with safety and economy'. On a subject dear to his heart, Mr. Clark emphasized his appeal for economy with maximum safety by reminding us that at 13 mA we reached the threshhold of 'let-go current'.

He dwelt at length on switchgear, on earthing, testing and maintenance and on portable equipment, illustrating his remarks with a multitude of examples and demonstrations.

Support for Chairmen

Hope is a much- if not ill-used word. It expresses, or has expressed from time to time, our very inmost feelings. No less feelingly was it used at both our opening meetings, by both retiring Chairmen, when they asked the Committees and membership for support for the new Chairmen.

Benevolent and Homes Funds

It has long been the custom of the North Midland Centre to hear, at an inaugural meeting, something of the work of the Benevolent and Homes Funds. On this occasion Dr. E. C. Walton, the Centre Honorary Treasurer for the Benevolent Fund, complimented the Centre and the Sheffield Sub-Centre on having raised £731 between them by special functions. This was increased by the sum of £24 10s. 6d. by a further appeal at the meeting.

Hydro and thermal generation

Two further meetings were held in November, and the appeals of the retiring Chairmen referred to above were not in vain, for both meetings were exceedingly well attended. That on the 2nd November 1961 was one of the all-too-few joint meetings with The Institutions of Civil and of Mechanical Engineers. The paper chosen for the occasion dealt with medium-head pumped-storage schemes in Great Britain and, in particular, described the Blaenau Ffestiniog installation. Our Senior Vice-Chairman, Dr. G. N. Patchett, opened the discussion and was followed by 11 other speakers—a clear indication of the interest generated in the audience.

The meeting on the 7th November 1961 was also somewhat special in the sense that it was again one of the all-too-rare occasions when the paper for the evening was by a local author, albeit a joint author. Mr. Painter gave Mr. H. J. Sheppard a special welcome, with a no-less-hearty greeting to the co-author, Mr. W. Casson, who, as he explained, was no stranger to the Centre. Together they gave their paper 'Technical and economic aspects of the supply of reactive power in England and Wales'. A short article based on this paper appeared in the June 1961 *Journal*, p. 377.

The paper and the authors' conclusions seemed to arouse more interest in the resultant problems associated with metering and tariffs, although Mr. F. Birch, in opening the discussion, dwelt at length on the difficulties in generating reactive power with the increasing electrical distance between the new larger generating stations and the load. Messrs. Sheppard and Casson dealt with the discussion with a clarity that pinpointed their grasp of the subject.

Hull District Meetings

The winter session of District Meetings in Hull began on the 19th October 1961, when a joint meeting with the Graduate and Student Section was held at the usual venue, the Yorkshire Electricity Board offices in Ferensway, Hull. The paper read was 'Transport and electrical traction'.

As a curtain-raiser to this meeting, the graduates and students paid a visit to Hull Docks and spent the afternoon inspecting electrical equipment for cargo-handling apparatus. After spending several hours looking round the docks, the graduates and students fully appreciated that Hull was the third-largest port in England.

During the summer, arrangements were made by Mr. Hilton for a party of members and friends to visit the troopship *Empire Wansbeck*, being refitted in Hull Dock. Great interest was shown in the bridge and engine room of the vessel, which is normally employed on the Harwich–Hook of Holland service.

H. A. C.

SOUTHERN CENTRE

Brushless variable-speed induction motors

On Wednesday, 29th November 1961, Dr. E. R. Laithwaite read at Southampton University a paper by himself, Prof. F. C. Williams, Mr. J. F. Eastham and Mr. W. Farrar. This paper was 'Brushless variable-speed induction motors using phase-shift control'. It is one of a series of important new papers on electrical machines that has emanated in recent years from the University of Manchester. A short review of this paper appeared in the January 1961 *Journal*, p. 25.

Dr. Laithwaite presented his paper in a brilliant manner and evoked much amusement from a good audience. It was felt by some of us present that anyone who could bring an audience to laughter on the serious topic of electrical-machine design was something of a master of his art, and this indeed is a true description of Dr. Laithwaite's position in this field of study.

Power factor

Prof. L. G. A. Sims of the University of Southampton referred to the remarkable sequence of inventions in design of variable-speed a.c. electric motors over the last 70 years, whereby interest in this subject appeared to revive very

strongly at intervals. He asked the author questions about the power factor of the brushless variable-speed induction motor described in the paper, calling attention to the fact that numerous other methods of obtaining variable speed from polyphase induction motors had mostly reached satisfactory commercial standards, in which, undoubtedly, good power factor was one of the primary considerations.

Dr. Laithwaite, in reply, admitted that the power factor of the new machine could be the subject of future improvement. However, he reassured Prof. Sims on the matter of waveform, which had also been mentioned. In reply to a further question by Prof. Sims, Dr. Laithwaite agreed that the application of the usual circle diagram in the prediction of performance of the machine was at present an impossibility.

Mr. K. Morgan raised with Dr. Laithwaite interesting questions on the subject of the end-turns in the winding of the 'short stator' that is characteristic of the new machine. Dr. Laithwaite agreed that Mr. Morgan's suggestions could be of importance and said he would consider them further on his return to Manchester.

University research

A vote of thanks was proposed by Dr. E. E. Ward. Dr. Ward pointed out that research of this kind, with a strong experimental basis and often aimed at elucidating questions that at first sight might seem somewhat inconsequential, was actually at the very heart of university research. The university was the place at which this type of inquiry could best be pursued and could frequently produce valuable results. Industrial research conditions did not permit the time to be spent pursuing something that might well turn out to be a misconception, but university laboratories could and should face that possibility. L. G. A. S.

SOUTHERN CENTRE ELECTRONICS AND CONTROL GROUP

Inaugural Meeting

THE Inaugural Meeting of the Group was opened on Tuesday, 10th October 1961, under the chairmanship of the Centre Chairman, Mr. T. G. C. Harrop. An early duty fell to him of introducing one of The Institution's Vice-Presidents, Dr. R. L. Smith-Rose, who represented the President for the occasion.

Beginnings of the Wireless Section

Dr. Smith-Rose recapitulated the beginnings of the Wireless Section of The Institution, its changes in title and its development up to its present dimensions, and remarked that, having started as a Wireless and then Radio Section, electronics became its subsidiary concern, but later this was reversed by electronics becoming the principal component in its title, with radio as a subsidiary. He also said that, although he was a member of the Pilkington Committee, he would not undertake to solve the television-line problem that evening.

Mr. E. Wolfendale was then invited by the chairman to present his Address, which was devoted to recent developments and applications of transistors. He outlined the u.h.f. problem, in which the limiting factor was the upper frequency limit that could be catered for, and the power problem, which was governed by the extent to which the equipment could be made to handle heavy currents and powers while still remaining cool enough. He was not to be persuaded to give a physical demonstration of an audio output of $\frac{1}{2}$kW, which he thought might be overpowering for his audience. The equipment was, nevertheless, there to be seen.

A 10kW inverter, switching 100A at 100V with the aid of silicon-controlled rectifiers, a miniature 4W rescue transmitter operating at 8·31 Mc/s, and a 100W transmitter operating at 5Mc/s and using silicon transistors were among his demonstrations.

He explained the method of improving the cooling of high-power transistors by lateral diffusion of current across the base of the transistor by using emitter and collector in the form of intermeshed combs. He concluded by asserting that transistors were destined to encroach more and more into the thermionic field and acknowledged the sterling efforts of his assistants in staging his remarkable demonstrations.

Encouraging local lecturers

The vote of thanks was moved by Mr. C. E. Tate. The chairman then inducted Mr. Wolfendale as Chairman of the Electronics and Control Group and explained that he would be in that Chair only for a short time, since he was leaving on the 1st December 1961 to take up a Senior Lectureship in the Royal College of Nairobi. Mr. Wolfendale, in taking the Chair, explained the purpose of the Group, which was to encourage the arrangement of programmes in Southampton, Portsmouth, Brighton and elsewhere and to persuade local lecturers to contribute to the programmes. This had been achieved in the past session, and it was hoped that it would be the continued pattern of future programmes. He expected that a feature of each year's programme would be a conversazione. It would give an opportunity for local people to demonstrate equipment that they were immediately concerned with.

The attendance at this meeting of 115 members and visitors, in the ratio of about 2 : 1, gave grounds to expect that the creation of the Group would provide much-needed facilities in the Southern Centre, and Mr. Wolfendale expressed his thanks to the membership for making him the first Group Chairman. R. G.

SCOTTISH CENTRE

Sub-Centre Chairman's Addresses

FOR his Chairman's Address to the South-East Scotland Sub-Centre on the 24th October 1961, Prof. W. E. J. Farvis spoke on 'The responsibility of the university to the electrical-engineering industry', a subject that followed most appropriately on that selected by the Centre Chairman at the previous meeting.

General aims

Prof. E. G. Cullwick had examined in broad outline the general aims of the engineering department of a university, while Prof. Farvis discussed in greater detail the requirements of an electrical-engineering curriculum to meet the needs of industrial leaders 10 or 15 years hence. A greater fundamental knowledge was required, he said, together with the development of a critical faculty to guard against too slavish a reliance on past experience.

The obvious interest aroused by the Address encouraged Prof. Farvis to discard precedent by asking for questions, and a lively discussion ensued.

Electricity in Dundee

Mr. G. L. Doig in his Chairman's Address to the North Scotland Sub-Centre at Aberdeen on the 27th October and at Dundee on the 28th October 1961 spoke on 'A city's electricity'. Mr. Doig outlined the development of electricity supply in Dundee since its inception in 1893 and mentioned, in particular, proposed schemes that had not materialized, such as an 8·5 MW tidal scheme, involving impounding the waters of Invergowrie Bay, and a 132 kV link between Dundee and Fife by a line crossing the Tay on three towers between Tayport and East Dundee.

Education in Scotland

On the 8th November 1961, the South-West Scotland Sub-Centre held the first of two exploratory meetings to observe the response that might be expected if an Education Discussion Circle were formed in Scotland. Dr. K. R. Sturley, a Past-Chairman of the London Education Discussion Circle, opened a discussion on 'Education—why bother?' After some general remarks on education, he outlined the main purposes of the Education Discussion Circle and Forum.

Long discussion

The audience of about 50 kept the discussion going for over two hours, most speakers holding the view that Scottish education is by no means maintaining the tradition that it set up 25 or 50 years ago and that a discussion circle could certainly help to restore the position. The success of this meeting augured well for the success and value of the proposed circle.

E. O. T.

LONDON REPORT

ORDINARY MEETING

GENERATION AND TRANSMISSION IN BRITAIN AND FRANCE

'NEVER before', concluded 'ancien Président' S. E. Goodall, 'have I heard so wide-ranging a discussion so clearly, unequivocally and objectively answered as in M. Ailleret's replies after the lecture this evening.' And this opinion was enthusiastically endorsed by all who came to hear M. P. M. J. Ailleret of Électricité de France deliver his lecture 'A comparison between generation and transmission problems in Great Britain and France' at an Ordinary Meeting at Savoy Place on the 26th October 1961. An article based on the lecture will appear in a forthcoming issue of the *Journal*.

The lecturer was a very welcome visitor. He has a long association with The Institution and is Oversea Representative of the Council for France. He is Deputy Director-General of Électricité de France, has been personally concerned in the negotiations that are now resulting in the construction of the cross-Channel Anglo-French power link, and has for many years encouraged interchange of ideas and technical information among engineers, especially through such international organizations as the International Conference on Large Electric Systems and the World Power Conference.

The interest that M. Ailleret's visit aroused was well indicated by the large audience, widely representative of electricity-supply and plant-manufacturing staffs, who listened attentively to the lecture and later took full advantage of his offer to answer questions. The President, Mr. G. S. C. Lucas, was in the Chair, and having announced that the meeting was being held jointly with the British Section of the Société des Ingénieurs Civils de France, he cordially welcomed their members and, in particular, their President, Mr. Bryan Donkin.

Lag between Great Britain and France

The lecturer began with load curves illustrating the similarity of the rate of increase of electrical-energy consumption in the two countries (7% p.a.) and pointed out that the difference in the respective stages of development was equivalent to a lag of about six years in France. Allowing for this difference, the installation of steam plant in the two countries had followed parallel courses—France, having decided to install 125 MW sets ten years ago, had maintained this policy until two years ago, when the basic size was increased to 250 MW per set. Now, 500 MW generators were being studied.

About half the electrical energy of France was generated at hydro stations, mainly in the south and south-west of the country. According to the latest estimates a total of 80×10^9 kWh/year could be developed—about twice the present output—but some of these new sources would need

London report (continued)

improved methods of construction if they were to be economic. In order not to encourage overexpansion of hydro-plant manufacturing facilities, Électricité de France had decided to limit the rate of new installations to the equivalent output of about 10×10^9 kWh/year.

With energy production almost equally divided between thermal and hydro, pumped storage was not economical in France. Assistance at peak would continue to be afforded by extra generators at the hydro stations, and there might be some extension of the use of gas turbines. In the Rance estuary, work had started on a scheme for harnessing the tides, embodying 24 bulb-type dual-flow units, each of 10 MW capacity; this project was regarded as a major experiment, and successful operation might lead to much larger schemes elsewhere.

Nuclear generation of power

Although for nuclear generation the two countries had confined their development work to the graphite-moderated gas-cooled reactor using natural uranium, the lecturer found a strange contrast in the respective plant-construction programmes, in that while Britain, almost independent of imported fuel, was constructing a sequence of large nuclear stations, France, importing some 35% of her fuel requirements, had limited her nuclear construction to successive-sized steps on one site only.

At Chinon on the River Loire, EDF1 station (now due to start up in 1962) would have an outdoor 82 MW generator and a reactor safeguarded by a containment sphere, the latter for exploratory investigations. Station EDF2 (due 1963) would have one reactor and two outdoor 125 MW generators. Station EDF3, for which the foundation work had just started, would comprise a single 375 MW reactor, which it was hoped would finally provide sufficient steam for two 250 MW generators.

Principal voltages and power interchanges

The northern portion of the French transmission system was not unlike the British network, but south of Paris the 380 kV connections were basically interconnectors for the hydro generation. The principal voltages in France would be 15 kV (probably to become 20 kV later), 60 kV, 225 kV and 380 kV. Present intermediate-voltage systems operating at 30 kV and 150 kV were being eliminated. The recent changeover of southern trunk lines from 225 kV double-circuit single-conductor to 380 kV single-circuit twin-conductor arrangement had been made possible by a special design of tower. New 380 kV lines would be single-circuit type on a modified tower, having what was described as a 'cat's head' superstructure, which was thought to be aesthetically more acceptable than the earlier design.

Present interchanges of power between France and seven adjacent countries did not, in either direction, exceed 2% of the national consumption, and the net annual exchange was less than 1%. For the cross-Channel link, the economic incentives for exchange were greater when account was taken of the different sources of energy, the different costs of production, and diversity between the load curves; the cable rating of 160 MW would permit the reliability and the utility of the link to be tested, so that the justification for a larger circuit could be examined later. One important benefit from all these links was the opportunity that they provided for contact between the supply engineers concerned and for exchange of technical experience and opinion.

Questions and answers

In answering questions after the lecture, M. Ailleret referred to trials of a pipe that might make possible the transport of natural gas across the Mediterranean from Algeria, expressed doubts about the need for earth wires on overhead lines controlled by auto-reclosing circuit-breakers, firmly supported the outdoor location of h.v. switchgear and transformers and expressed a preference for single-circuit lines in the interest of security of supply, stated that in France prestressed concrete poles were economically satisfactory for 15 kV lines while steel was easily the cheapest material for the towers of lines operating at 60 kV and upwards, and, in discussing future trends in transmission, urged the importance of obtaining international agreement on the next standard-voltage level.

The President reluctantly brought the discussion to a close, and Mr. Donkin's expression of thanks was most warmly supported by an audience who had remained interested and undiminished in number to the end. F. J. L.

DISTRICT MEETING AT READING

DIRECT CONVERSION

MR. Forbes Jackson presided at the first meeting of the session, held at the George Hotel, Reading, on Monday, 16th October 1961, which was well attended, when Dr. K. H. Spring gave a talk entitled 'Direct conversion'. Dr. Spring outlined the conventional method of electricity generation, namely the steam turbo-alternator, and mentioned its limitations. After detailing the alternative sources of energy available and the various methods of their direct conversion to electrical energy, he confined discussion to those more promising for high-power production.

Alternative energy sources

Dr. Spring discussed the Edison effect, the Seebeck effect, the magnetohydrodynamic (m.h.d.) effect and the fuel cell and described in some detail the thermionic convertor, the piezoelectric convertor, the m.h.d. convertor and the Bacon

cell. In comparing the possible efficiencies of these methods with those achieved by the conventional turbo-alternator, it was clear that direct conversion was unlikely to replace the conventional method but its use as a topping unit to improve the efficiency of the conventional plant was justified; and possible arrangements for achieving this were considered.

The talk stimulated a long and interesting discussion, at the conclusion of which the speaker was warmly thanked for his talk and the able way in which he had presented his subject.

R. G. H.

DISTRICT MEETING AT OXFORD

THE DEVELOPING ENGINEER

THE first District Meeting at Oxford of the 1961–62 Session was held on Wednesday, 11th October 1961, when Mr. J. E. L. Robinson spoke on 'The developing engineer'. This talk was based on his Chairman's Address to the Supply Section and considered three aspects of the problem. A shortened version of this Address appeared in the January 1961 *Journal*, p. 14.

Three aspects

The first aspect was the training of engineers, where there was a need for broadening the outlook of present courses by introducing studies of the humanities. At the same time it was becoming most necessary for the layman to have a better knowledge of the part technology played in present-day society.

Secondly, the speaker referred to the effect of a 'breakthrough' in many fields of technology. Fundamental advances in semiconductors, insulating materials and nuclear power had changed the whole pattern of electrical-engineering development. For this reason an engineer's training must be such as to allow him to exploit these advances and not struggle to keep alive obsolete practices with which he had grown up.

Finally, Mr. Robinson considered the engineer engaged on development work and posed many provocative problems that he felt worthy of attention for the advancement of electrical-engineering science.

Failure of present system

The talk was followed by a most lively discussion, in which the topic receiving most attention was that of the education and training of engineers. There was a general feeling that the present system failed to give the young trainee engineer sufficient responsibility, especially an opportunity to make mistakes, and there was a risk of stultifying his development and the enthusiasm so necessary for tackling the great range of problems to which Mr. Robinson had referred.

The meeting concluded with a vote of thanks proposed by Mr. D. N. Cornish on behalf of the 52 members and friends present.

R. C.

EDUCATION DISCUSSION CIRCLE

DIGITAL COMPUTERS AND ELECTRICAL ENGINEERS

THE first meeting of the 1961–62 Session took place on the 17th October 1961 at Savoy Place with Mr. J. K. Webb as chairman, when Dr. P. D. Aylett opened a discussion on 'The place of digital computers in the teaching of electrical engineers'.

Normal pieces of equipment

In his opening remarks, Dr. Aylett said that, in view of the rapid expansion of computer capacity, students would inevitably meet computers as pieces of normal equipment during their future career. In the present state of rapid technological development, students should be taught the possibilities of the use of computers as calculating tools and for control purposes, in addition to any design considerations. This might call for some modification of syllabus content, although such matters as numerical methods of solution and principles of logical design should, in any case, have their place in an electrical-engineering course.

Problems previously raised by programming techniques were likely to be diminished, as the more modern machines required a knowledge of only relatively simple techniques that could be mastered very quickly. Examples of programmes for simple problems using a particular code were given in support of this point.

Experience and programme codes

A full and lively discussion followed this opening. Several speakers were able to base their remarks on experience with computers in their own colleges, and these were generally in support of the inclusion of work on computers in the curriculum. It was pointed out that, after only two or three hours' instruction on programming, students were able to make practical use of a computer. It was an advantage that a very clear understanding of the steps involved in the solution of a problem was necessary in order to write the required programme. Students showed much interest and, in at least one case, were willing to give time voluntarily to a study of the use of computers in addition to their other studies.

Further discussion centred on the various programme codes, and reference was made to a basic-function code that emphasized the fundamental steps of the computation. The value of a computer as a tool during the course was also

London report (continued)

stressed, it being claimed that in this way subjects such as network analysis and control systems could be dealt with in greater depth than would otherwise be possible.

It was thought by others present, however, that students were indicating a failure to grasp fundamental theory that was causing much concern. More attention should be paid to the teaching of fundamentals and to the development of an insight into engineering principles. Techniques such as the use of computers could be very quickly obtained after the completion of the basic course and should not be allowed to take up valuable time during the course itself.

G. R. A. T.

INFORMAL MEETING

ALUMINIUM OR COPPER CONDUCTORS?

THE metal traditionally associated with conduction of electricity is copper. At the period when practical applications for electric power were being developed, the physical and electrical qualities of copper, together with its availability, made it the natural choice for conductors of all kinds. The advent of aluminium on a commercial scale introduced an alternative conductor material of much lighter weight, an attribute that electrical engineers lost little time in exploiting.

Both metals have extensive use in the electrical industry today and rival one another in many applications. A review of their respective claims as conductors will be the subject of an Informal Meeting to be held at Savoy Place on the 22nd January 1962. The discussion will be opened by Mr. J. C. Bailey of the Aluminium Development Association and Mr. T. L. Richards of the Copper Development Association.

BULLETIN OF THE SECTIONS

SUPPLY

VISITE SUR LA CÔTE D'ÉMERAUDE

ON Wednesday, 6th September 1961, by air and steamer, members of the Section and their ladies headed for Dinard, the centre chosen for the Summer Visit. True, the party, totalling 150, were not at full strength until those travelling overnight had arrived. Hence, the first morning was left free for individual arrangements.

General aerial view of St. Malo
The Rance estuary is shown in the background

St. Malo testing station

The weather had set fair, and crossing by launch to St. Malo on Thursday afternoon was a pleasant passage. The party were received at the model of the River Rance scheme by M. G. Mauboussin, Directeur de la Région d'équipement marémotrice of Électricité de France. The model covered several acres and utilized a dock. The facilities enabled a detailed study to be undertaken of a scheme to harness the tides of the Brittany coast. Differences in level amounting to 45ft occurred, and, with the natural storage area of the Rance estuary sealed off at the seaward end, the entrapped water would ultimately be used to drive 24 10MW generators sited in the dam.

The studies in progress had required an exhaustive examination of the tidal effects on the estuary, and a scale model representing its topographical features was housed in a large building. Here it was possible to simulate various tidal conditions and examine the effects of sluices, locks and other controls. The practical aspects of generator functioning had been supplied by installing a 9MW machine of the axial-bulb type, similar to those to be used, at the entrance to a disused dock. Demonstrations were given of the set functioning, and M. Courcambeck and his colleagues gave

an interesting and informative picture of this unique undertaking.

Conducted tours

The party returned to Dinard to spend the evening according to taste and next morning set out for a conducted tour of St. Malo. The chequered history of the city, when unfolded by the guides, proved fascinating, and admiration was aroused by the assiduous devotion that has been shown in rebuilding it after the wanton destruction that took place in 1944. Lunch was provided by Électricité de France and was presided over by M. Mauboussin. Members were also delighted to see M. R. A. Tellier and his wife among the hosts and were occasioned amusement when reading the local paper describing the event to find one distinguished Past-Chairman described as the 'ancien Président'.

The party were taken to Dinan by coach, and a brief tour was concluded by tea. The return journey was by river steamer. While the Rance is not comparable in magnificence with the Rhine, nevertheless the two-hour journey downstream gave great pleasure. Past fishermen with huge picturesque nets, dredger barges and other river traffic, glimpses were obtained of hamlets on the sides of the estuary, where in some cases the corn mills had been operated by tidal power for many generations.

At the site of the dam, the river was half a mile wide, and the steamer was manoeuvred to give members close views of the civil-engineering activities. Caissons were already being positioned to form the coffer-dams to protect the work proceeding on the site of the future sluice gates, and the lock on the left bank was in an advanced state of construction.

Dinner-dance

On Friday evening there was the traditional dinner-dance, when the Section were hosts to the friends who were responsible so kindly and ably for the arrangements associated with the Visit. Under the chairmanship of Mr. J. E. L. Robinson, assisted by Mrs. Robinson, a welcome was extended at the Dinard Casino to the Électricité de France officials already mentioned and their ladies. During the evening, the company were entertained by a local group of folk-dancers and musicians dressed in colourful costumes.

End of Visit

The weather continued excellent, and mid-morning on Saturday saw the party at Mont St. Michel. Conducted round the wonderful Abbey, all were able to appreciate the beautiful architecture and the many interesting features of the edifice. Lunch was taken at a restaurant on the ramparts. The party progressed onwards by coach to the ancient cathedral city of Dol. Many were delighted by their short exploration, especially as the colourful preparations for a fête day enlivened the setting on the pleasantly warm sunny afternoon.

So the time for those returning by steamer inevitably arrived, and the company started to depart. All carried away lasting and happy impressions of the penultimate Visit of the Section.

F. C. W.

UTILIZATION

RESEARCH IN ELECTRICITY UTILIZATION

The first meeting of the 1961–62 Session, which was graced by the presence of a number of ladies of members and also honoured by the attendance of the President, Mr. G. S. C. Lucas, took place on the 12th October 1961, when the incoming Chairman, Dr. H. G. Taylor, delivered his Inaugural Address 'Research in the field of electricity utilization'.

Wide range of applications

The Address surveyed a very wide range of applications, particularly those projects that had engaged the attention of the British Electrical and Allied Industries Research Association, and covered such matters as agriculture, horticulture, space- and water-heating, radio interference, flameproof equipment and welding. In connection with the last subject, the exhibition of a particularly high-speed colour film of welding in process was most fascinating and aroused great interest.

Mr. C. D. Wilkinson voiced the thanks of all those present to Dr. Taylor for his most interesting and instructive Address and, in referring to his remarks on horticulture, said that in his experience in his own garden the suggested use of electricity to make two blades of grass grow in the place of one was quite unnecessary.

Following the formal installation of Dr. Taylor as the new Chairman of the Section, the President very fittingly remarked that he would like to take the opportunity of being the first to welcome the new Chairman and to extend to him his best wishes for a most successful year of office.

New Divisional structure

In the course of his remarks, the President referred to the proposed alterations in the structure of The Institution in the near future, one of whose effects would be the disappearance of the Utilization Section—along with the other specialized Sections—as such. He pointed out that this proposal had been put forward only after very long and careful consideration by the Council, and he felt quite sure it was in the best interests of The Institution and its members in the changed conditions that now existed and would occur in the immediate future.

No doubt, all those listening to the President's words suddenly realized that this particular Utilization Chairman's Address would, in all probability, be the last, and the writer

of these notes, who was a member of the first Committee of the Section when it was formed in 1941, could not help feeling some regret that this would also probably mean that the Section would be unable to celebrate its coming of age next year. Nostalgic feelings of this kind, however, must quite rightly give way to any steps that are in the best interests of The Institution.

Mr. R. A. Marryat then thanked the retiring Chairman, Mr. J. M. Ferguson, for all his untiring efforts during his term of office. This was supported with considerable acclamation, following which Mr. Ferguson suitably replied. R. H. R.

MEASUREMENT AND CONTROL

SPACE-TIME BEHAVIOUR OF NUCLEAR REACTORS

A PAPER 'The use of analogue computers in predicting the space–time behaviour of nuclear reactors' by Mr. R. W. Hockney and Dr. T. O. Jeffries was presented at a meeting at Savoy Place on the 24th October 1961. Mr. W. S. Elliott was in the Chair. A short review of this paper appears on p. 742.

The paper was introduced by Dr. Jeffries, who gave us the vital statistics of the Saturn analogue computer that was used for the solution of these problems, utilizing axial and radial equations and four delayed neutron groups. The paper had a dual aspect, being concerned both with nuclear reactors and with mathematical computation methods. The introduction was continued by Mr. Hockney, who was more particularly interested in the computational aspects. He told us how non-linear terms caused trouble in the use of the continuous form of equations employing harmonic-type analysis. In such cases, the finite-difference perturbation model was still valid and was to be preferred. Instabilities in the reactor due to feedback from moderator temperature to reactivity gave rise to interesting analyses, and an example was quoted that utilized 17 harmonics.

The reactor and computation

The ensuing discussion was of a high professional calibre and about equally divided between interest in the reactor and interest in computation. Mr. D. F. Hiorns, in opening the discussion, pointed out that, now that the Central Electricity Generating Board's nuclear reactors were going on stream, we were entering a new era when it was possible to have a cross-check on reactor designs. He gave it as his opinion that, in the future, perhaps fundamental studies would demand even larger analogue installations. He invited the authors to comment on the feasibility of analogue computers larger than the Saturn computer. Several other speakers were interested to hear the authors' experience and opinions on using large-scale analogue assemblies. Mr. Hiorns also thought that modal analysis might be necessary in the interest of reducing computer size; he wondered how this method compared for accuracy.

Mr. R. A. Laws contributed some remarks based on experience in the C.E.G.B. of the use of finite-difference methods. Mr. R. L. Carstairs described a method he had utilized of representing the distance variable in an axial-stability study as the time variable, using an X/Y plotter. He wondered whether the authors had found, as he had, that the ratio of voltage dividers to amplifiers in a nuclear-reactor simulator was altogether higher than normal. Dr. B. Wilson wished to know whether the harmonic technique could be used for large transients by establishing new steady states as the computation proceeded. Dr. P. B. Bransome contributed some good-natured banter from the digital-computer gallery.

Authors' reply

The authors in their reply told us that they had used as many as 1500 amplifiers at one time, the maximum on any one problem having been 500. In doing this, they had experienced no particular problems once the system was going, but adequate checking was a very important matter. Practice had been to calculate the steady states digitally and not to proceed until agreement was obtained to within 1%. This meant that it took about one week to set up a 200-amplifier problem: it might then be used for anything up to 12 months thereafter, with minor changes in parameters. Interesting use was made of the digital programme to detect faulty amplifiers by a point-to-point comparison of response. This method cut down fault-detection time very considerably.

The authors had found that considerably more voltage dividers were required, in the ratio of about 4 : 1, and that as many as 80% of the voltage dividers were used on any one problem. In reply to the many questions on this subject, the authors were persuaded to divulge a few more details of their experience. They told us that they had obtained 80–90% 'operatability' and that the reliability of the valves, which were special-quality ones, had proved to be far greater than they had expected. Mr. H. A. Wright had asked why digital tape storage was not used for monitoring signals on the analogue, and Mr. Hockney in his reply said that he felt that such an arrangement would be an advantage.

Non-partisan

It was clear that the authors maintained a very good balance of appreciation of the advantages of both analogue and digital methods and were not partisan in their opinions on this matter. One felt that they spoke here with the voice of experience, and it was encouraging to hear that both modes of computation had their appropriate spheres of advantage. The meeting was concluded with reluctance, but with the audience feeling that they had learnt something of interest during the evening. J. H. W.

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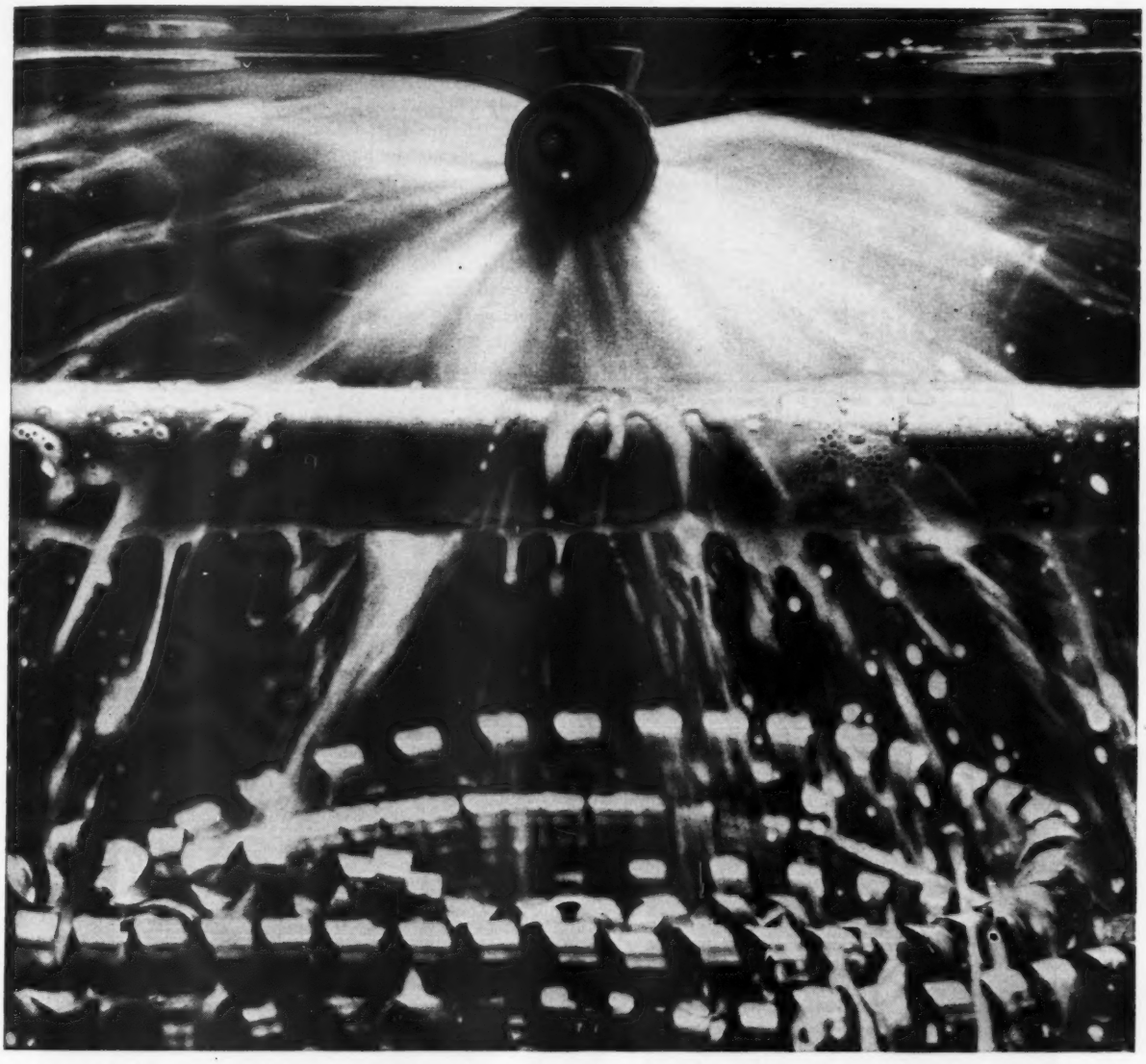
Shell demonstration



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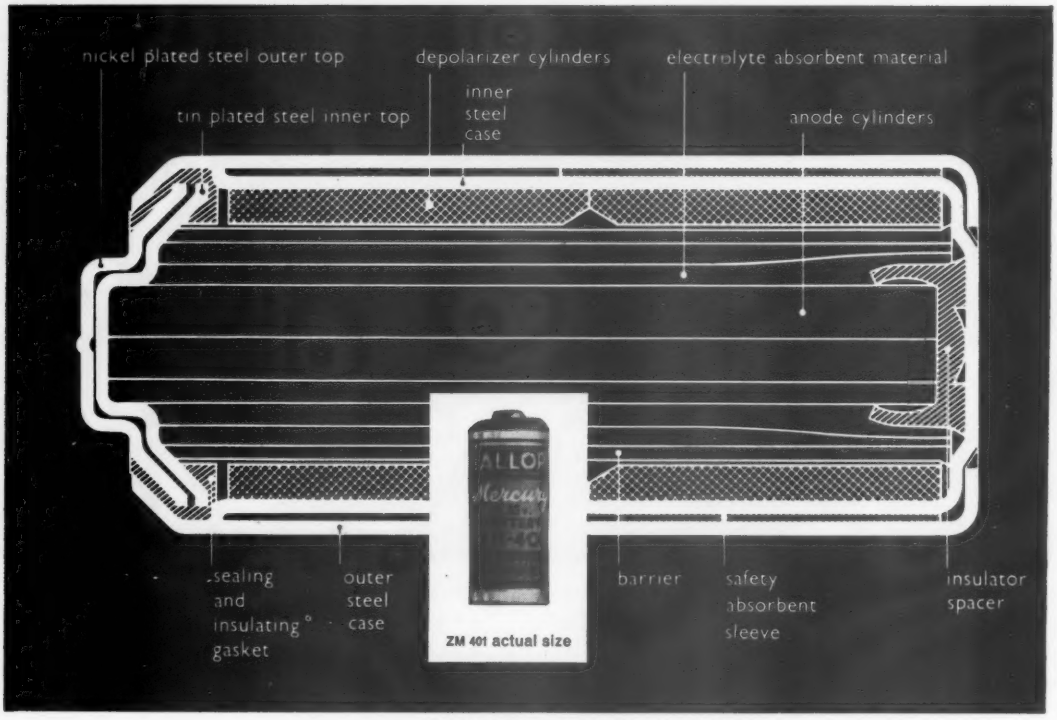

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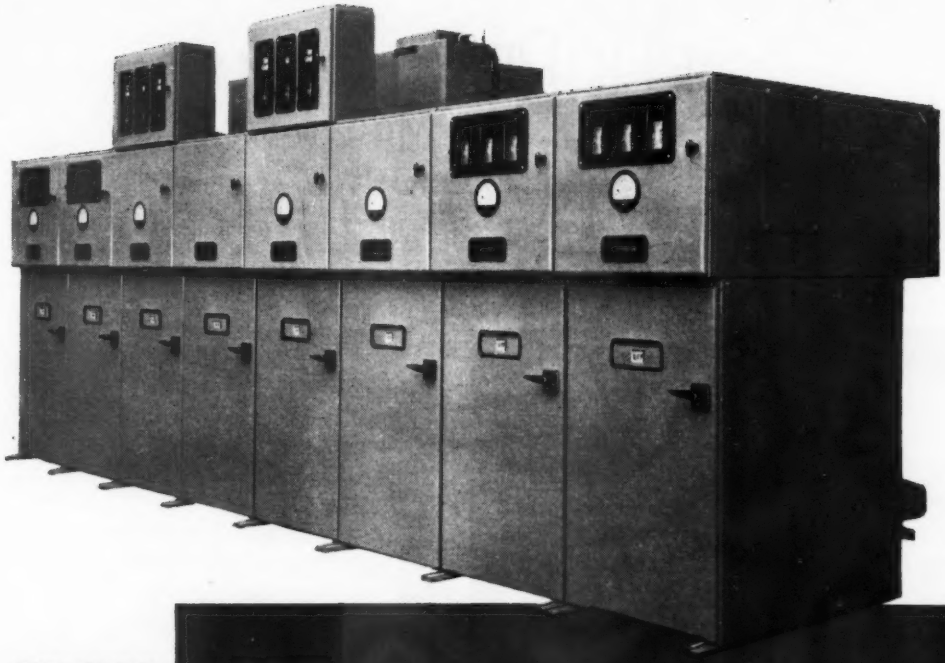

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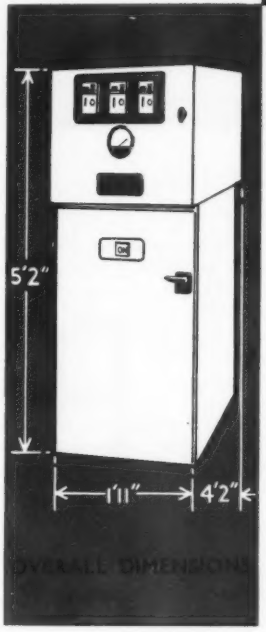

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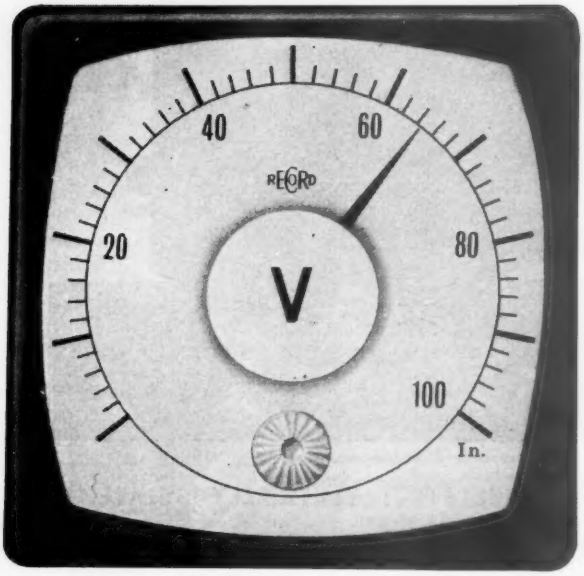
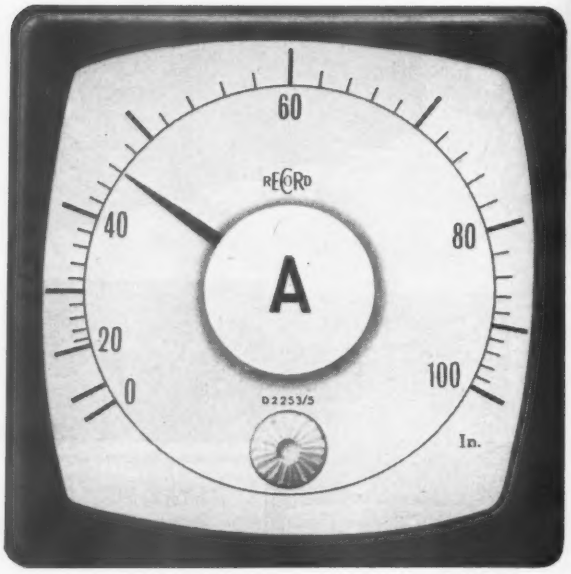


Moving Coil

ACTUAL SIZE



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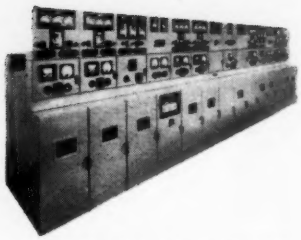
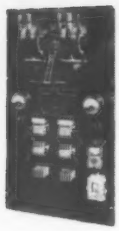
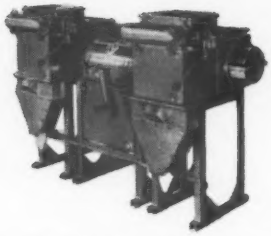


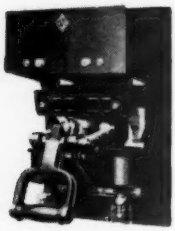
11 K.V. Metalclad Switchboard (Air Insulated)



Heavy Current D.C. Circuit Breaker and Knife Switch Panel



H.V. Ring Main Switchboard with Fuse Switch controlling Tee-Off



Small Air Circuit Breaker

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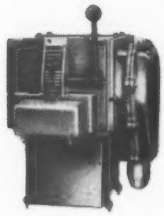
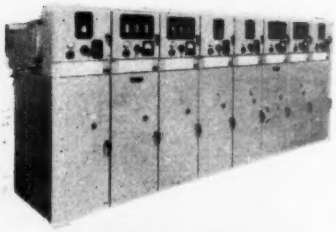
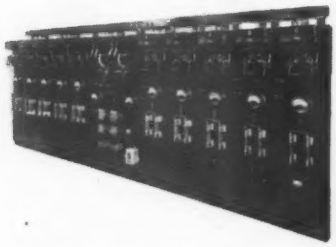


L.V. Industrial Oil Circuit Breaker

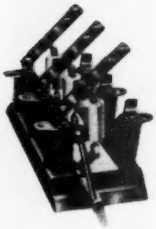


11 K.V. Metalclad Switchboard (Compound Filled)

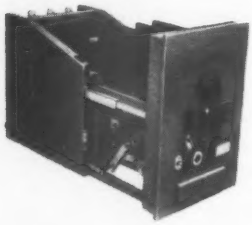
Panel Mounting Knife Switch



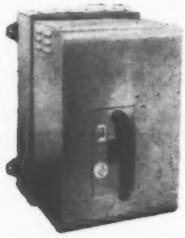
D.C. Switchboard for Steel Works



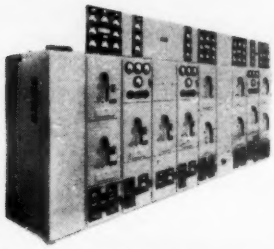
T.P. 11 kV Isolating Switch



L.V. Draw-out Air Circuit Breaker



L.V. Metalclad Air Circuit Breaker



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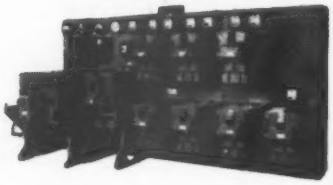

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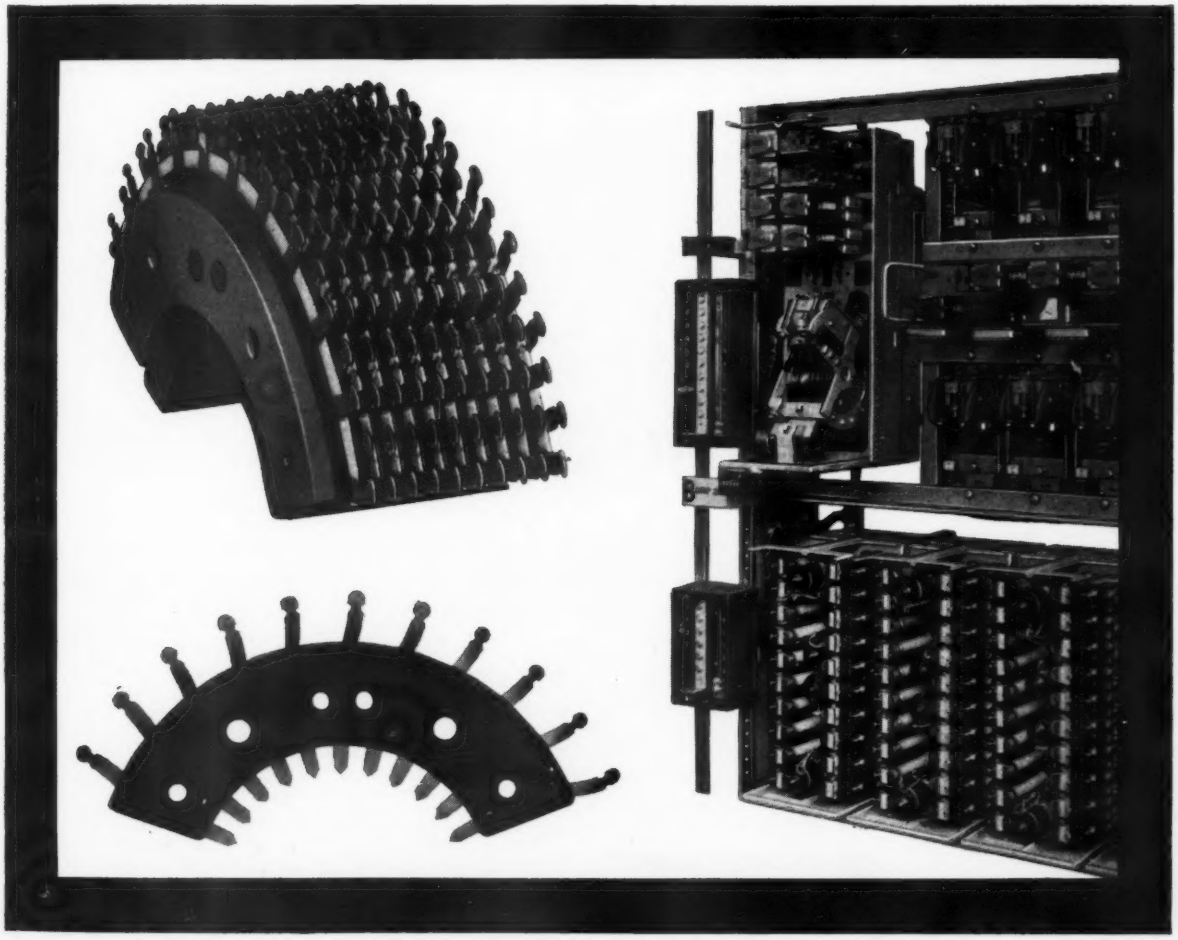

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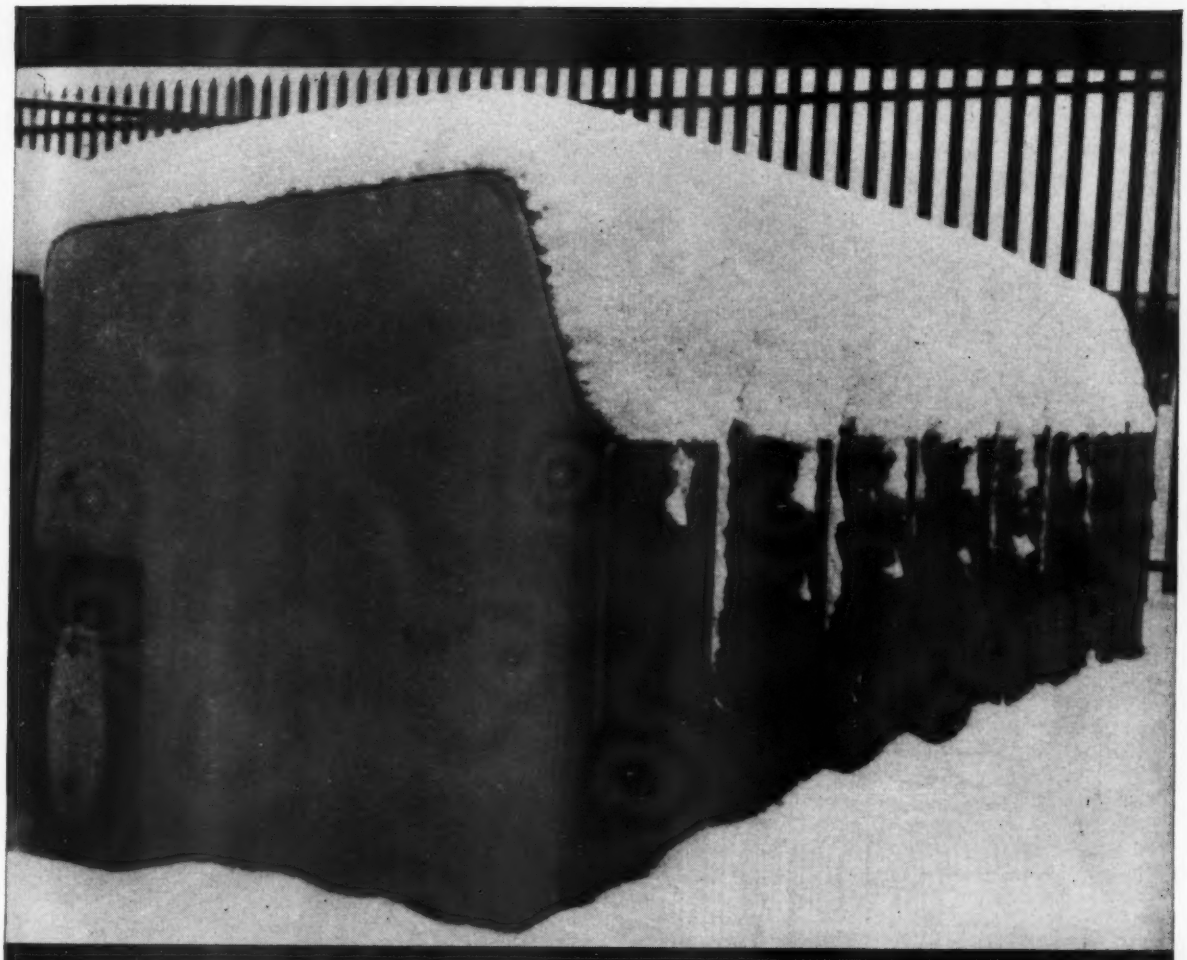

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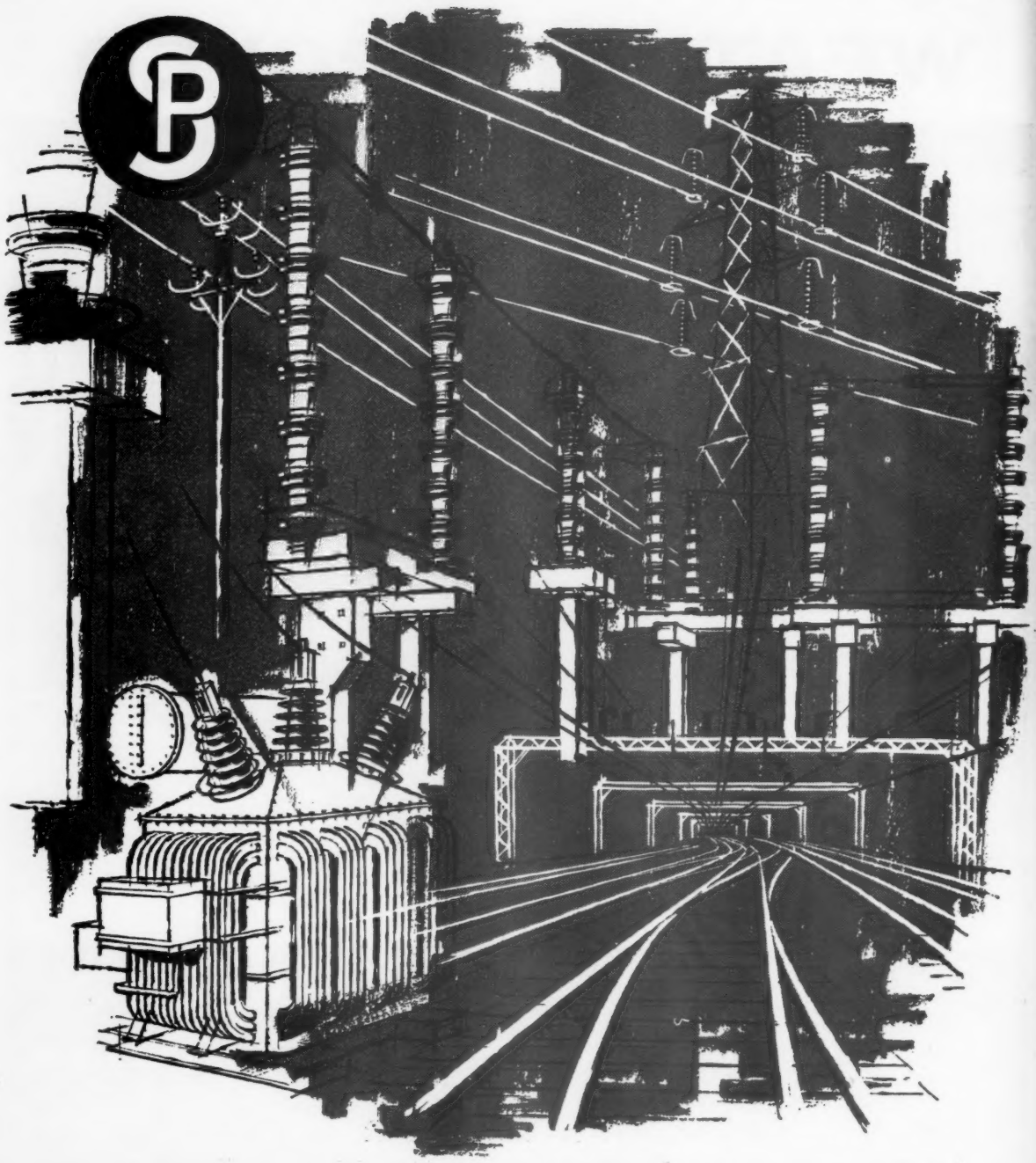

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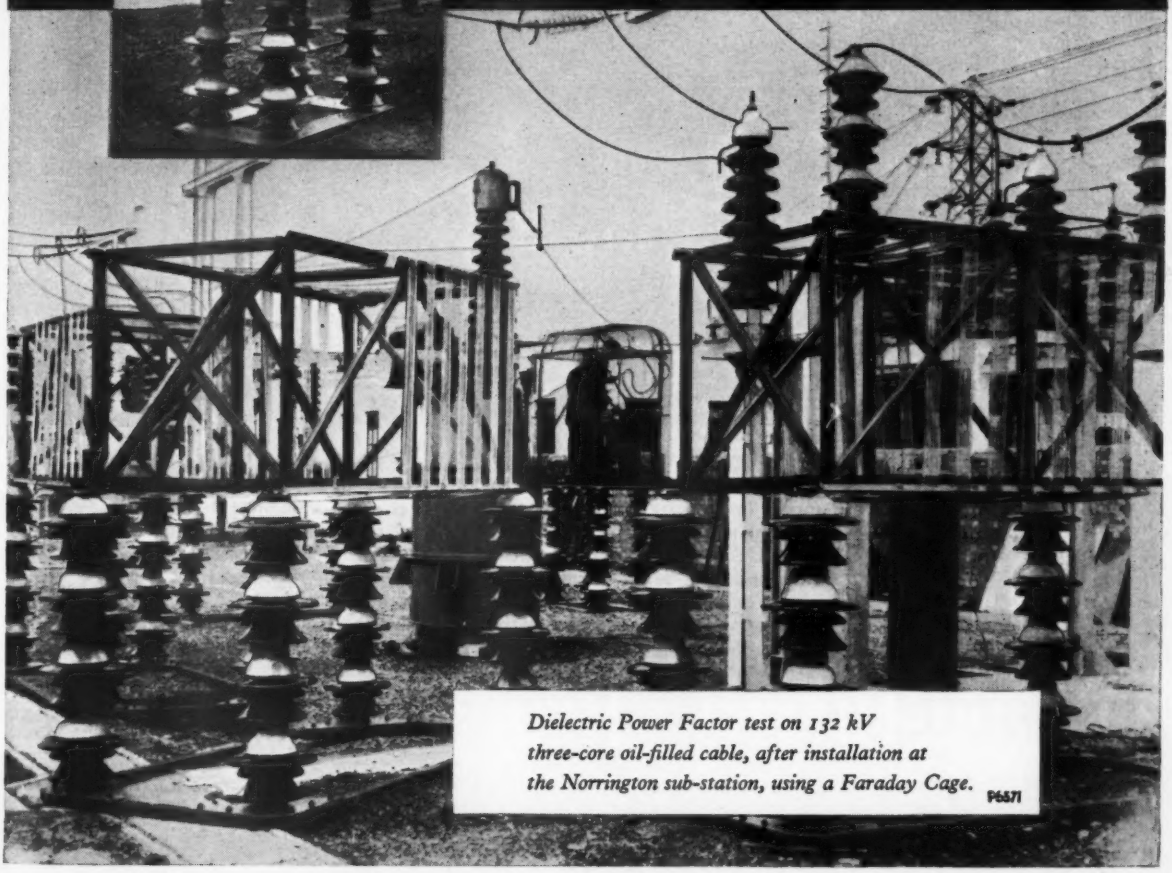

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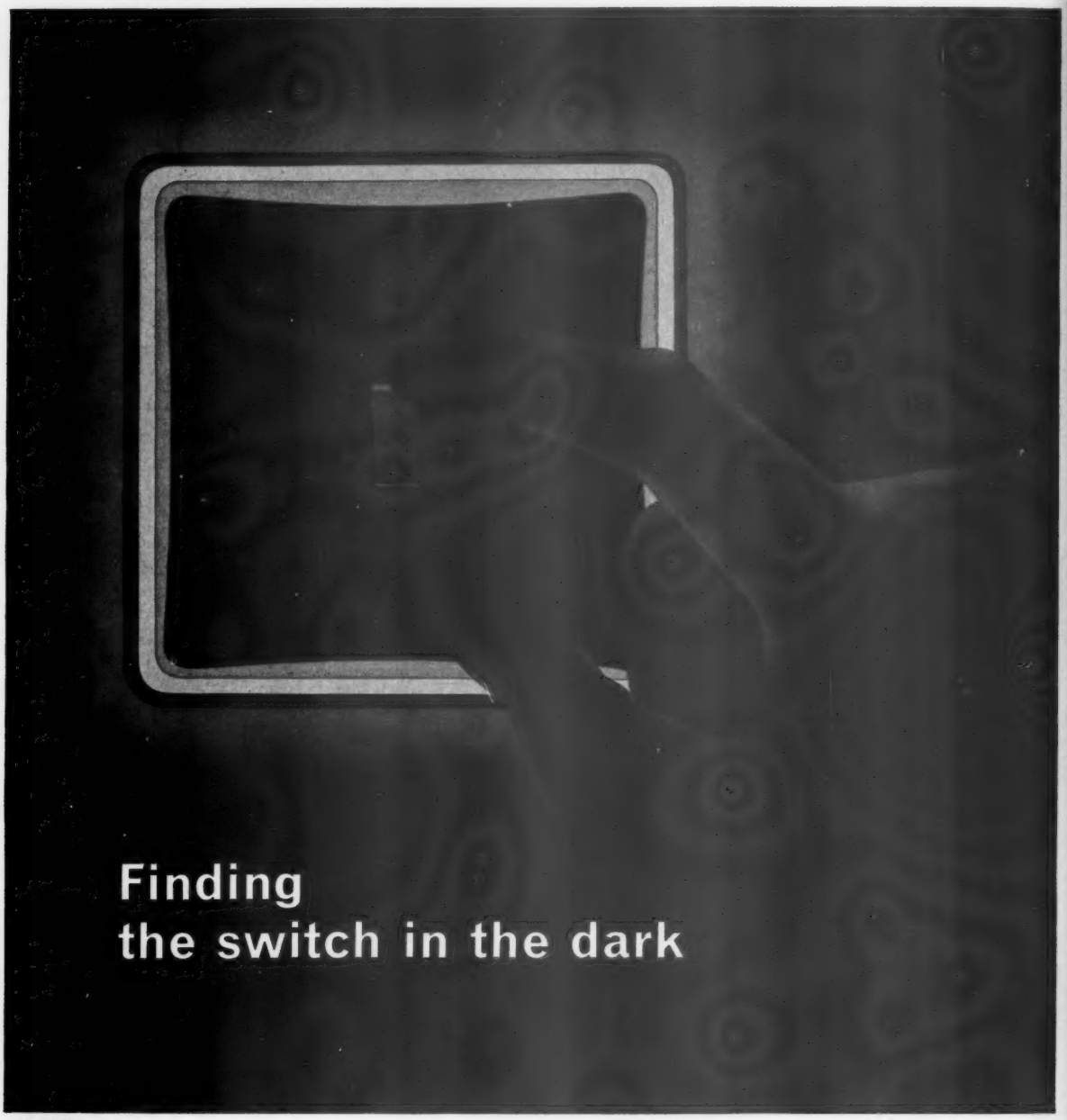

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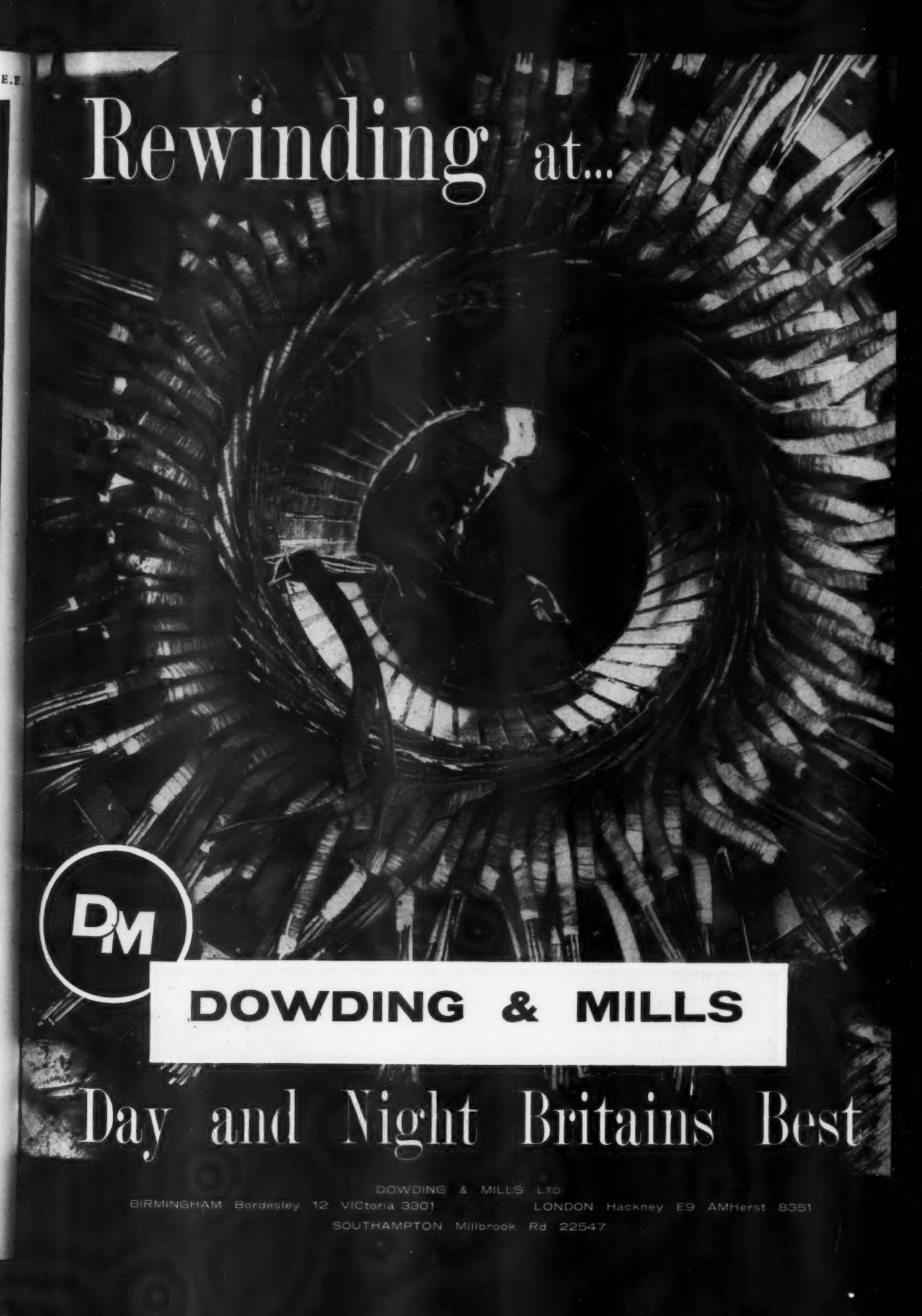
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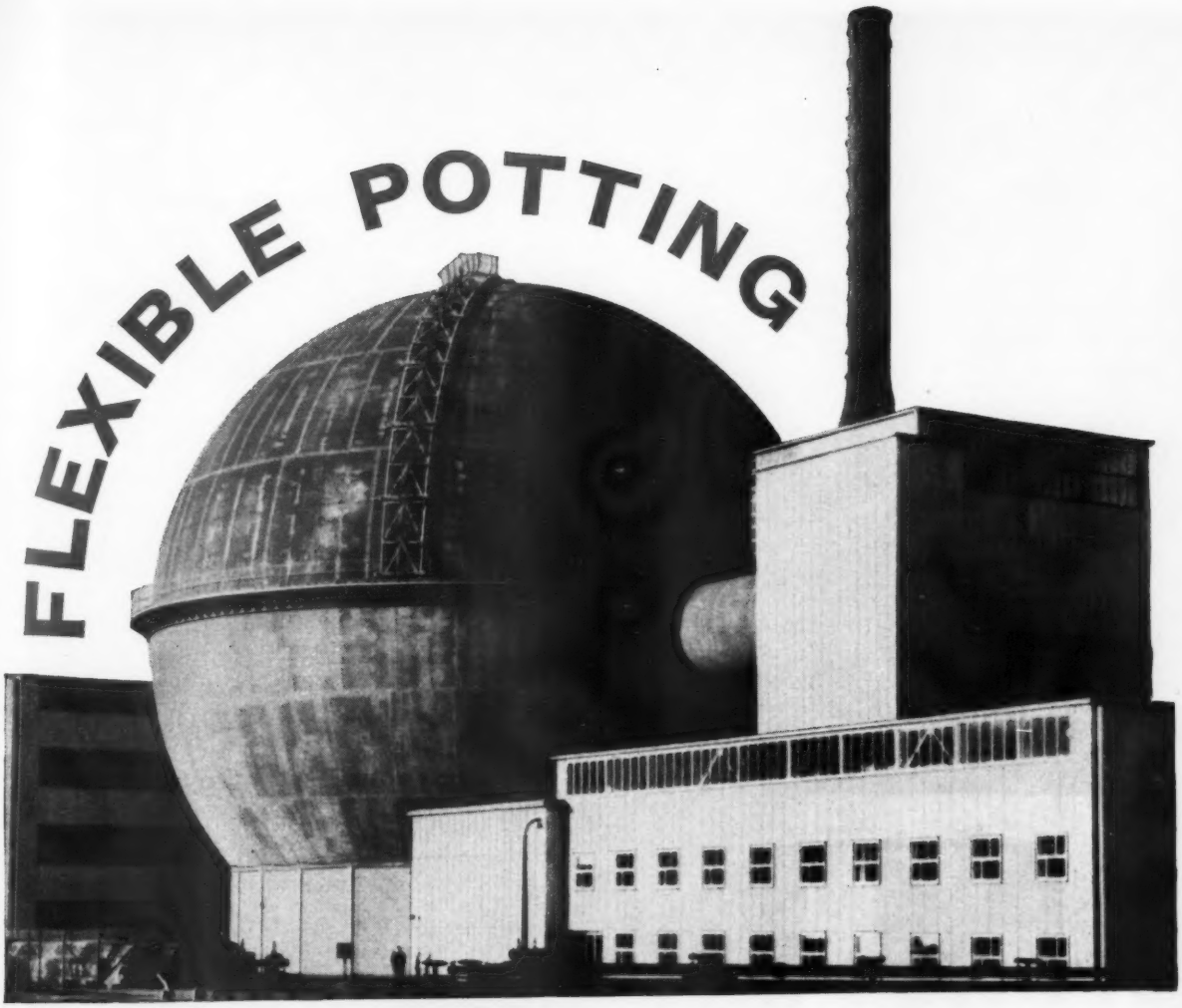

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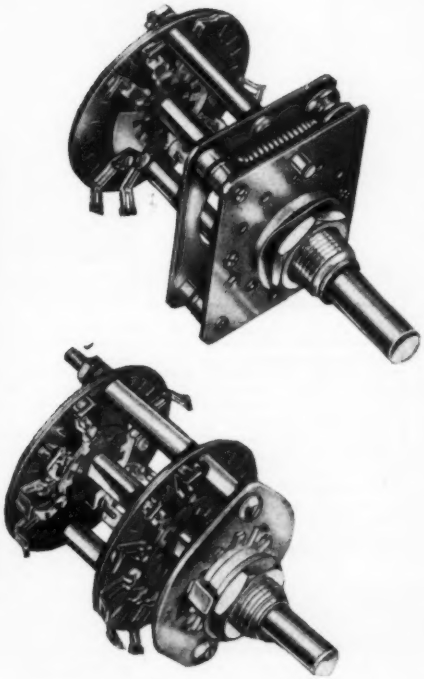

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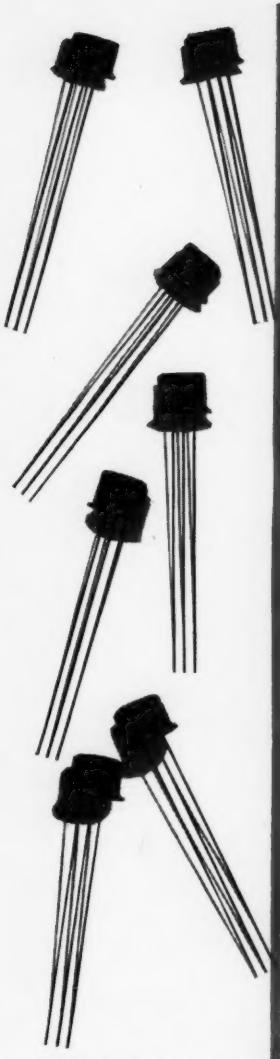

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Very low leakage currents

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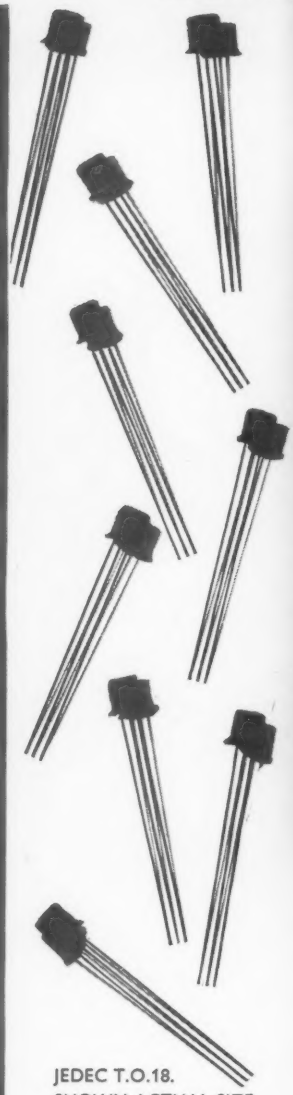
will be supplied on request



JEDEC T.O.18.
SHOWN ACTUAL SIZE

MAXIMUM RATINGS AT 25°C AMBIENT						
	ZT20	ZT21	ZT22	ZT23	ZT42	ZT43
Collector Base Voltage	20	20	45	45	45	45 volts
Collector Emitter Voltage	20	20	45	45	45	45 volts
Emitter Base Voltage	6	6	6	6	6	6 volts
Collector Current	50	50	50	50	50	50 mA
Total Dissipation	350	350	350	350	300	300 mW
Temp. Range operating and storage	—55 to +150°C					

CHARACTERISTICS							
	ZT20	ZT21	ZT22	ZT23	ZT42	ZT43	Test Conditions
Common Emitter D.C. Current gain h_{FE}	18—42	38—82	18—42	38—82	18—42	38—82	V_{CE}=6V I_C=10mA
Common Emitter A.C. Current gain h_{FE}	30*	45*	30*	45*	30*	45*	V_{CE}=6V I_C=1mA
Collector Saturation Voltage Max. V_{CE} sat	0·5V	0·5V	1·0V	1·0V	1·0V	1·0V	I_C=10mA I_B=2mA
Gain Bandwidth Product. Min f_T	70mc/s	70mc/s	70mc/s	70mc/s	70mc/s	70mc/s	V_{CE}=6V I_C=10mA

* Typical Values

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offer a wide range of SILICON SEMICONDUCTOR DEVICES

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FE 223/2

Plessey

Aerial Exchange feeds 80 receivers from one aerial

- 2 Mc/s to 30 Mc/s overall coverage; uses four basic units.
- Optional additional units link any receiver to any of several arrays.
- Standard unit range speeds maintenance, simplifies installation.
- Complete system gives ultimate capacity of 80 receivers working to 12 aerial arrays.
- Electronic switching minimises noise, heightens long-term reliability.
- Zero overall insertion loss; high-gain, low-noise wideband amplification.
- Easily arranged for dual-diversity working.

Comprehensive details of this flexible range of equipment are available on request.

Telecommunications Division · Electronic and Equipment Group
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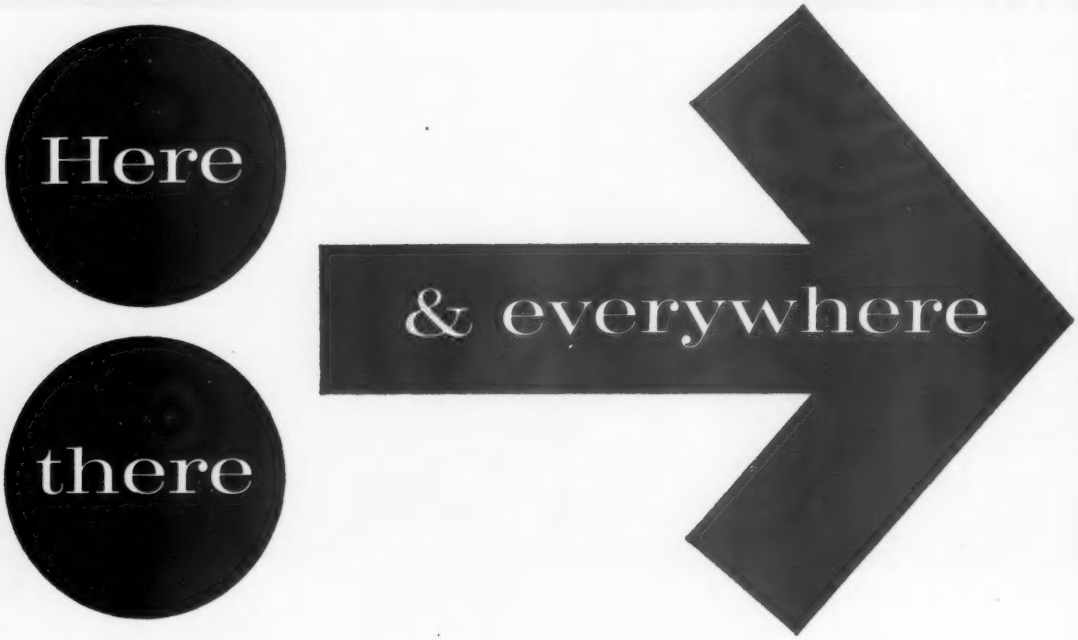
Overseas Sales Organisation: Plessey International Limited

Class H



Class H and Class C silicone-insulated dry type transformers are in the centre of things nowadays—in general use *at load centres*. And it doesn't matter if it's on the 1st or the 17th floor, in the factory roof or next to the warehouse. Class H and C dry-type transformers are *safe*—anywhere. Not affected by dust or humidity. Fire and explosion proof. And because they withstand repeated overloading, ratings need not be based on peak loads.

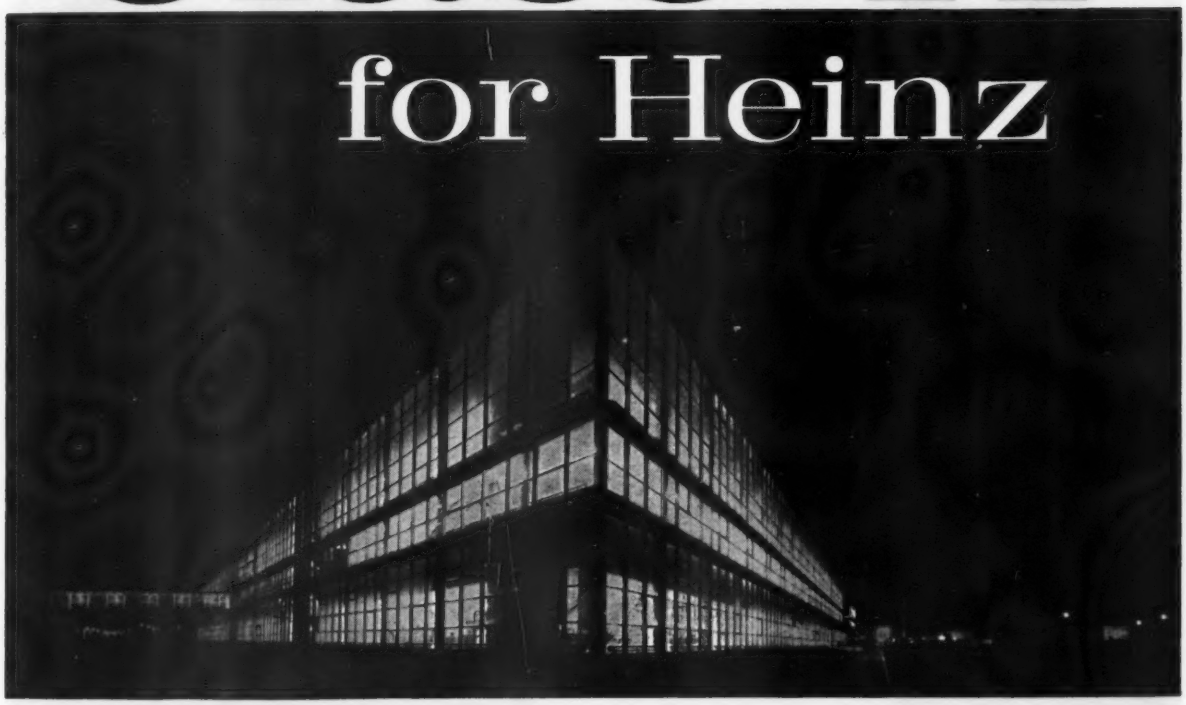
Among the leading firms and organisations using Class H and C transformers are *Shell, Unilever, The Steel Company of Wales, Vauxhall Motors, Ford Motors, Rolls-Royce, Pilkington Brothers, Central Electricity Generating Board, National Coal Board, Air Ministry, The BBC* and *British Railways*.

For safety, reliability and low maintenance costs, silicone-insulated transformers hold every advantage.

MIDLAND SILICONES supply the silicone resins and elastomers for Class H and C transformers. Such transformers are manufactured by the following companies :- *Associated Electrical Industries (Manchester) Ltd · Bonar, Long & Co Ltd · Brentford Transformers Ltd · Brush Electrical Engineering Co Ltd · Crompton Parkinson Ltd · Denis Ferranti Co Ltd · The English Electric Co Ltd · Ferranti Ltd · Foster Transformers Ltd · The General Electric Co Ltd · Gresham Transformers Ltd · Hackbridge & Hewittic Electric Co Ltd London Transformer Products Ltd · C A Parsons & Co Ltd · Bruce Peebles & Co Ltd · South Wales Switchgear Ltd · Transformers (Watford) Ltd · Woden Transformer Co Ltd · The Yorkshire Electric Transformer Co Ltd.*

MS

Class H for Heinz



Three thousand people at Kitt Green, the new Heinz factory near Wigan, share a brand new building with FOURTEEN Class H transformers.

Smaller and lighter than oil-filled units, these fourteen BRUSH transformers, rated at 500 kVA, three-phase, 50 cycles, 6,000/433 volts, have been installed in a number of sub-stations on the mezzanine floor between the two main production halls. The reason for choosing Class H dry-type transformers is briefly stated by Heinz themselves:

"These transformers have been selected for reduced fire hazard, particularly with reference to the fact that most of them are installed within the main building. This gives an associated advantage of less complex design of Sub-Station and improved fire insurance arrangements."

There is no need for special enclosures, nor for special fire-fighting equipment, since Class H transformers are fire and explosion proof. Having transformers *anywhere* in the factory, at load centres, means low-voltage cable runs are very much shorter and floor excavations are rarely needed.

If you are not already a recipient of our regular news bulletin on the applications of silicones, 'MS News for Industry', please write for a copy.

MS

MIDLAND SILICONES LTD ***first*** *in British Silicones*
(Associated with Albright & Wilson Ltd and Dow Corning Corporation)
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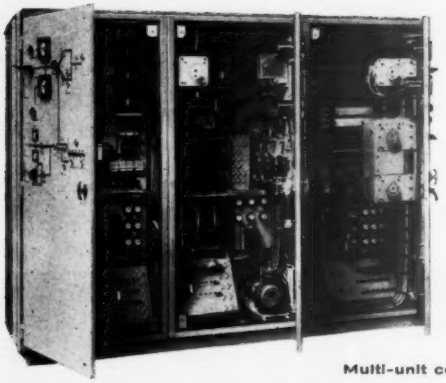
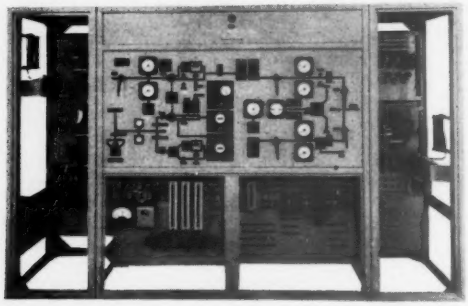
Area Sales Offices: Birmingham, Glasgow, Leeds, London, Manchester.

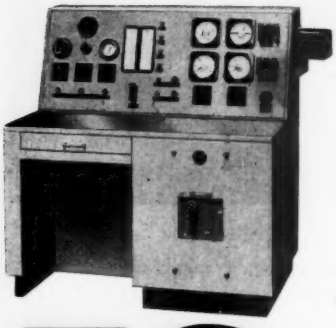
Agents in many countries



Multi-unit control cubicle.



Mimic diagrams are supplied where necessary.



Central control console.

50 YEARS IN CONTROL

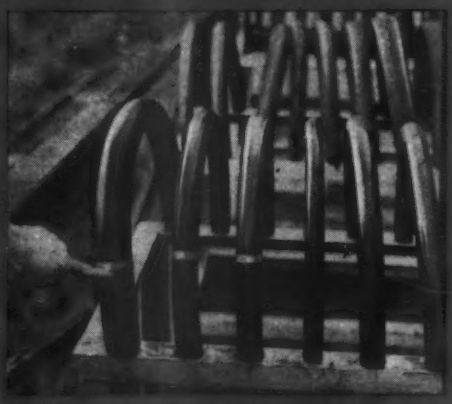
Since 1910 PELAPONE LIMITED have pioneered many original developments in Automatic Rotating Plant—which in turn necessitated similar progression in automatic controls. Today, Pelapone Automatic Control Systems cater for all industries employing automatic production processes or requiring remote control and indication. Integrated systems can be designed to serve a wide range of inter-dependent plant. Design, manufacture and installation services are available.

PELAPONE LIMITED

SALES DIVISION:
STEEL HOUSE, EASTCOTE, MIDDLESEX, ENGLAND. Telephone: PINner 5881 Cables: Pelapone London.
WORKS: P.O. BOX 4, DERBY.

DU PONT NEOPRENE IS JOB-TESTED TO TAKE THE TOUGHEST PUNISHMENT

Resistance to heat. Handling oil-treated coke at temperatures of 180° F. calls for a conveyor belt with all the toughness and durability of Du Pont neoprene. This particular belt made from neoprene has carried over a million tons of coke without failure.



Resistance to weather. These test lengths of hose made from Du Pont neoprene have been exposed out of doors for 18 years to the ravages of weather, ozone and sunlight. They show no cracking or deterioration.

Resistance to abrasion. Transmission and V-belts made from Du Pont neoprene are highly resistant to abrasion from dusty conditions in factories. They also withstand friction heat and flex fatigue.

DU PONT NEOPRENE offers an impressive *combination* of properties. Maintenance products made from neoprene effectively resist *many* deteriorating influences, not just one or two. What deteriorates rubber parts at your plant? Is it abrasion, oil and grease, extremes of temperature, sunlight, weather, ozone, chemicals? Du Pont neoprene is the one elastomer that stands up to *all* of them—or any *combination*.

For further information on products made from Du Pont neoprene contact your supplier or write direct to Du Pont Company (United Kingdom) Ltd., 76 Jermyn Street, London S.W.1

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Established 1802

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Du Pont Company (United Kingdom) Ltd., 76 Jermyn Street, London, S.W.1, England. *Please send me the Engineering Guide to Du Pont elastomers.*

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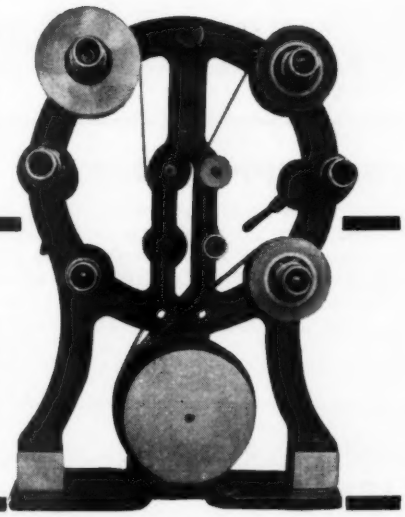
INT. INSTN. OF ELEC. ENGS. 2/61

This transformer coil costs less, weighs only half as much– it's wound with **aluminium strip**

Coils wound with aluminium strip not only have better electrical and thermal characteristics: they are simple to make and show appreciable savings in material costs. Because they have none of the air spaces unavoidable with round wire, they are generally no larger than wire-wound coils of equal power and weigh only half as much. If you would like to know more about strip windings, or other uses of aluminium in the electrical industry, get in touch with any of the Alcan Industries' offices listed below.



SIMPLE TO MAKE

The winding technique is very simple, needing no costly winding equipment with traversing gear. The coils can be wound on to their cylindrical formers without flanged bobbins. Service and advice are freely available to firms interested in strip winding techniques.

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Makers of Noral Alloys

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TBW/N61

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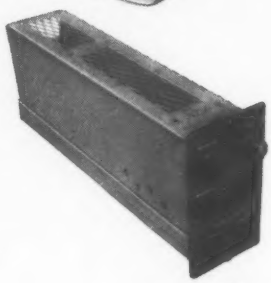
WITH NEW EQUIPMENT FROM SAVAGE & PARSONS

DIRECT WRITING OSCILLOGRAPH RECORDER

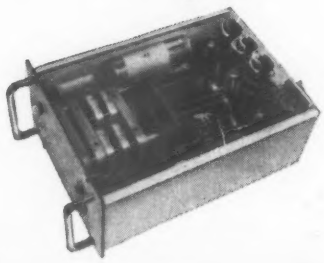
PERMANENT records can be obtained continuously or intermittently at 8 paper speeds, from 5 inches per minute to 150 in. per sec. Image is visible on 6 in. wide ultra-violet sensitive paper without processing. The recorder has 12 channels plus 3 additional galvanometers for use as time, event, or datum reference lines. This highly accurate unit is designed for recording strain, pressures, flow velocities, and temperatures under continuously varying conditions. *Write for Publication 3/30.*

DRIVER AMPLIFIER



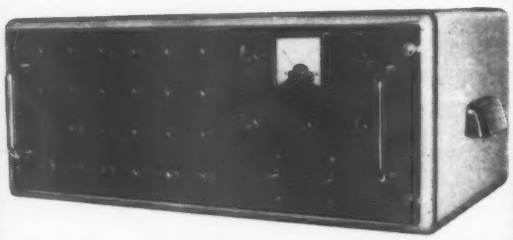
This push-pull valve/transistor amplifier with high input impedance (3M. ohms) and low output impedance (less than 20 ohms) is ideally suitable for driving galvanometer used in the Oscillograph Recorder. There is a feedback for gain stability and linearity. *Write for Publication 3/40.*

POWER SUPPLY UNIT



The unit provides stabilized voltage for up to 3 amplifiers. There are 3 voltages: + 150V d.c., −150V d.c., and + 19V d.c. A thermal delay is included in the + 150V d.c. line to prevent violent fluctuations at the output of the amplifier when supplies are first switched on. No adjustments are necessary when the number of channels is altered. *Write for Publication 3/41.*

GAUGE SELECTOR/ CALIBRATOR UNIT



Designed for connecting, selecting and balancing groups of strain gauges for multi-channel recording. The unit also contains facilities for superimposing a calibrated signal on each channel. *Write for Publication 3/42.*

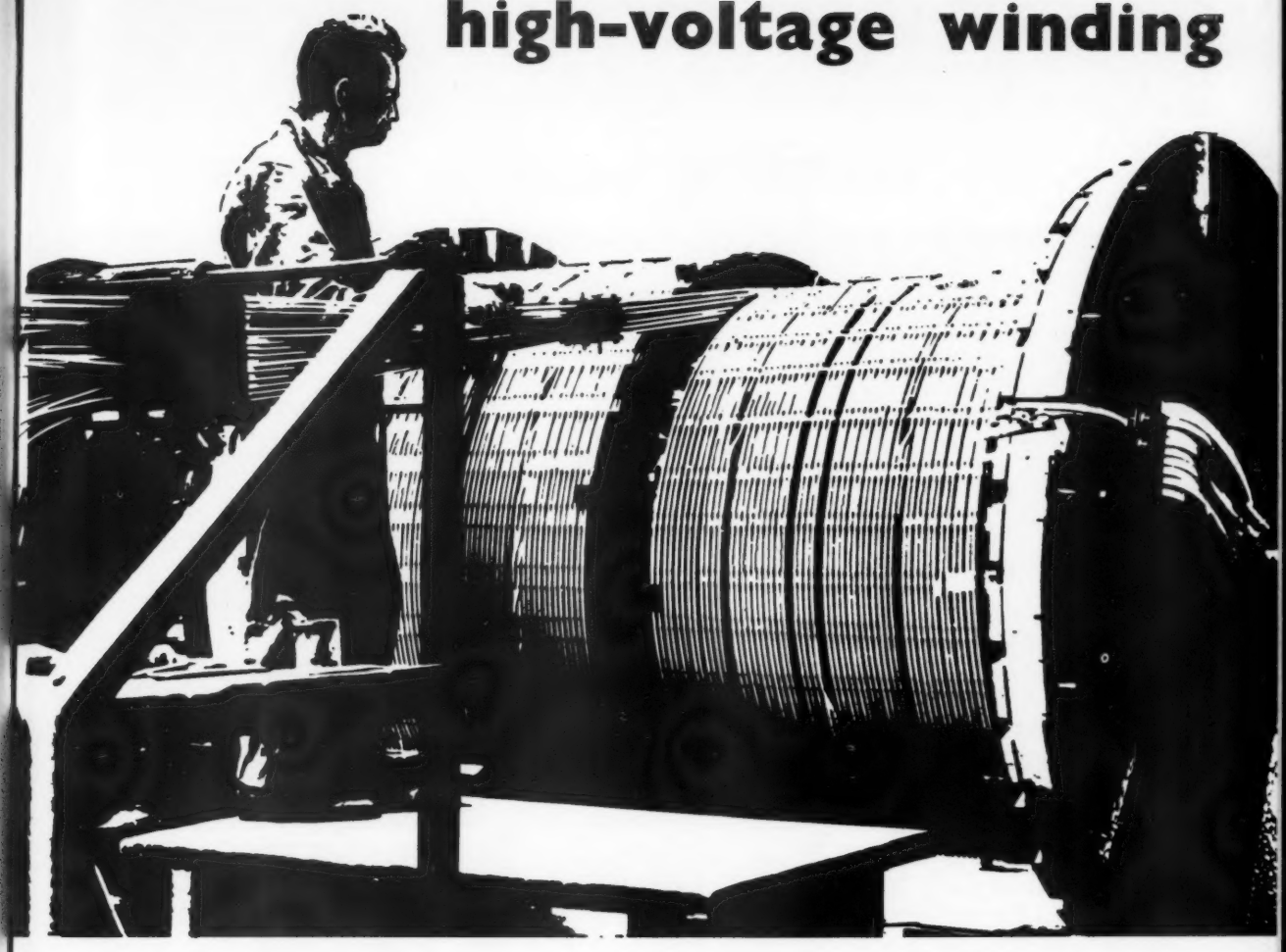
SAVAGE & PARSONS LIMITED

WATFORD HERTFORDSHIRE Telephone: WATFORD 26071

STATIC AND DYNAMIC STRAIN RECORDERS

TGA PR1

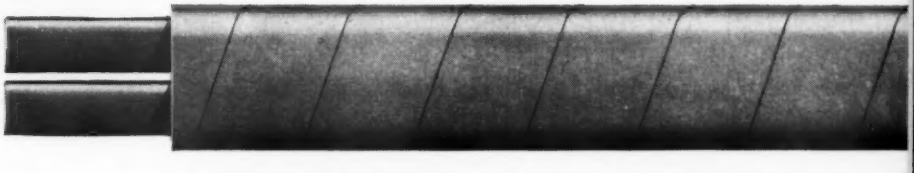
high-voltage winding



BICC Paper Insulated Strip on a Transformer at Bruce Peebles & Co. Ltd., Edinburgh

with

BICC PAPER COVERED STRIP



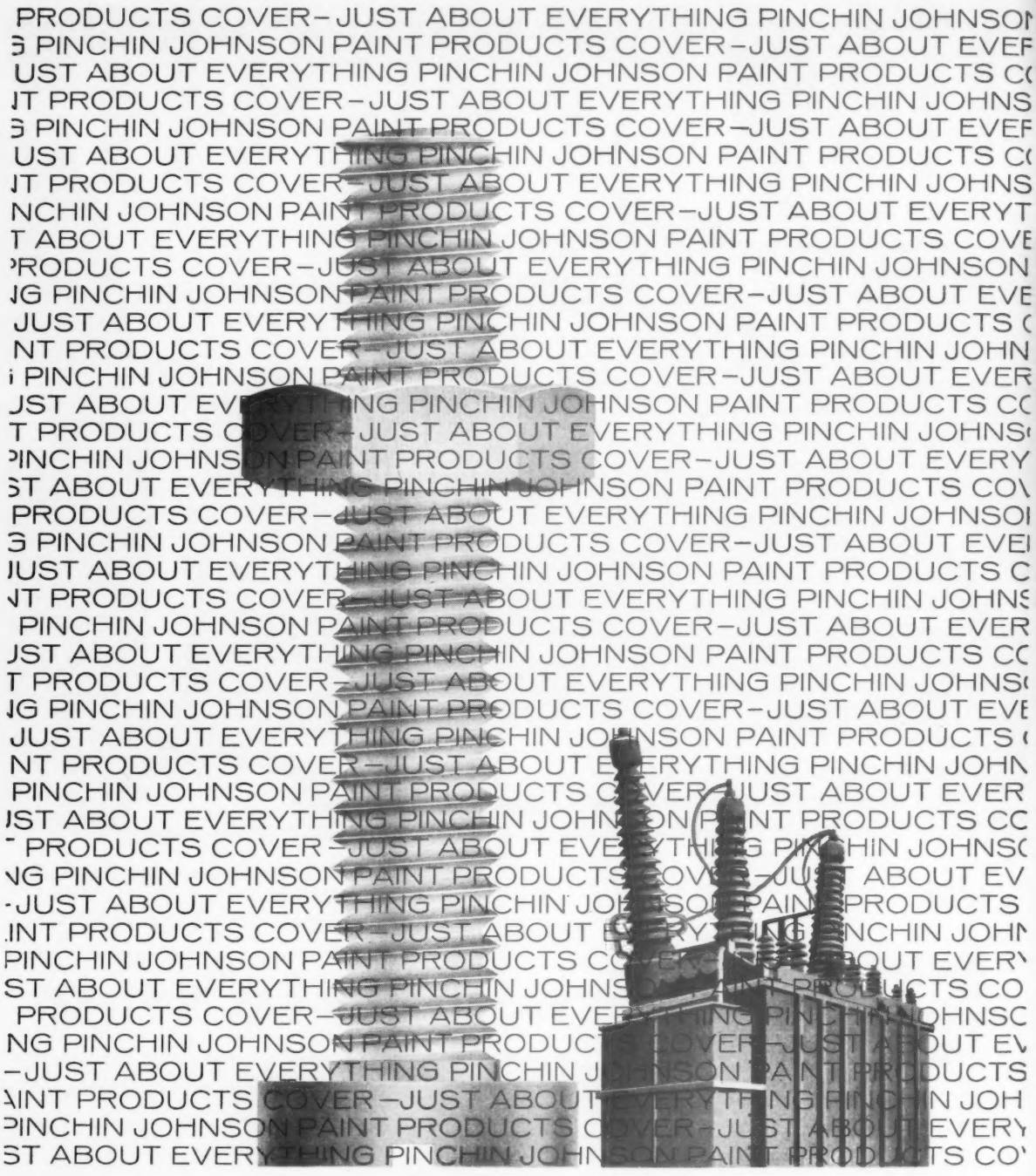
As a result of the development and installation of paper lapping plant of revolutionary design BICC Paper Covered Strip is now manufactured with a high degree of controlled registration of papers and is especially suitable for high-voltage transformer windings immersed in oil. The high quality paper covering can be applied to any practical rectangular section and caters for a wide range of requirements.

The recent installation of modern plant enables us to quote the most competitive deliveries.

Detailed information on BICC Covered Winding Wires and Strips is freely available from any one of 50 BICC Branch Offices. Write for Publication 382.

BRITISH INSULATED CALLENDER'S CABLES LIMITED

21 Bloomsbury Street, London, W.C.1



From minute electronic assembly to power engineering, electrical manufacturers make use of Pinchin Johnson products. Externally, protective paints—internally, specialised insulating enamels, varnishes and compounds ensure reliable operation in all conditions. Interesting or unusual applications of Pinchin Johnson products are described in every issue of *Top Cover*. Let us know if you would like to see future copies.

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PJA

When things get hot . . .

specify SILASTOMER insulated cables–to BS 3258

Lost in a cloud of hot gases . . . splashed by boiling chemicals . . . seared by the heat of a furnace, SILASTOMER cables continue to work — *safe and reliable for continuous operation at 150°C, or much higher temperatures for shorter periods.* SILASTOMER insulated cables also resist temperatures down to —50°C, steam at low pressure, water, weathering, corona discharge and electrical fatigue. Glass-braided SILASTOMER cables continue to function through and after the outbreak of fire.

These cables are also finding increasing use in installations where, due to difficulty of access, maintenance is a problem.

Wherever exceptional reliability is essential, specify SILASTOMER insulated cables.

The ability of cables insulated with silicone rubber to withstand long-term continuous use at a maximum conductor temperature of 150°C is the subject of a new British Standard. This Standard—BS 3258—was prepared at the request of the Cable Makers' Association, "in view of the increasing use of Silicone Rubber Insulated Cables and Flexible Cords".

SILASTOMER *is the registered name of silicone rubbers manufactured and sold by*

MS MIDLAND SILICONES LTD

(Associated with Albright & Wilson Ltd and Dow Corning Corporation)

first *in British Silicones*

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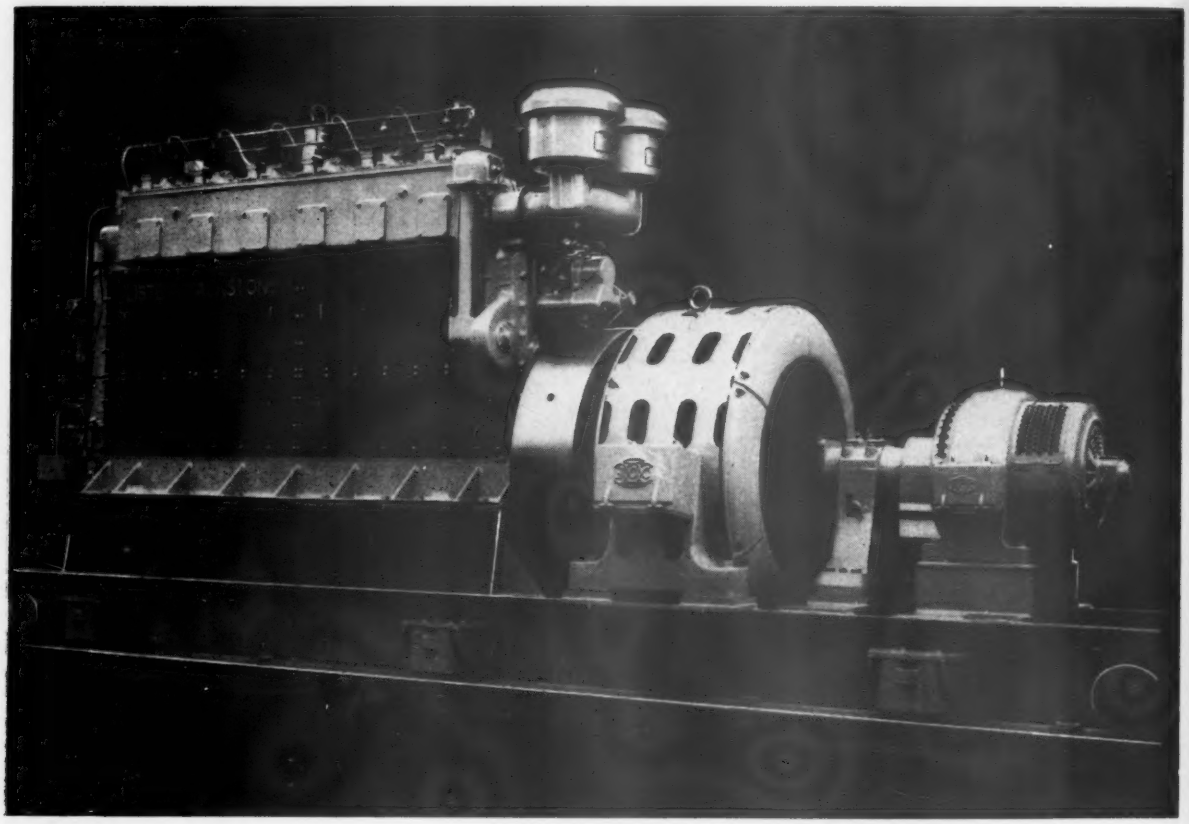

Lister Blackstone EVD F6 Dual Fuel six-cylinder engine.
270 H.P. 600 RPM.

Somebody's power problems are nearly over...

This Lister Blackstone Dual Fuel Engine and Generator is on its way to site where it will not only provide the electrical power required economically, but the heat from the jacket water and exhaust gases will be fed to a Heat exchanger from which the hot water will be used for process purposes etc. without additional fuel cost. May we send you the latest Lister Blackstone catalogue featuring diesel and dual fuel engines from 1½ to 1600 B.H.P.

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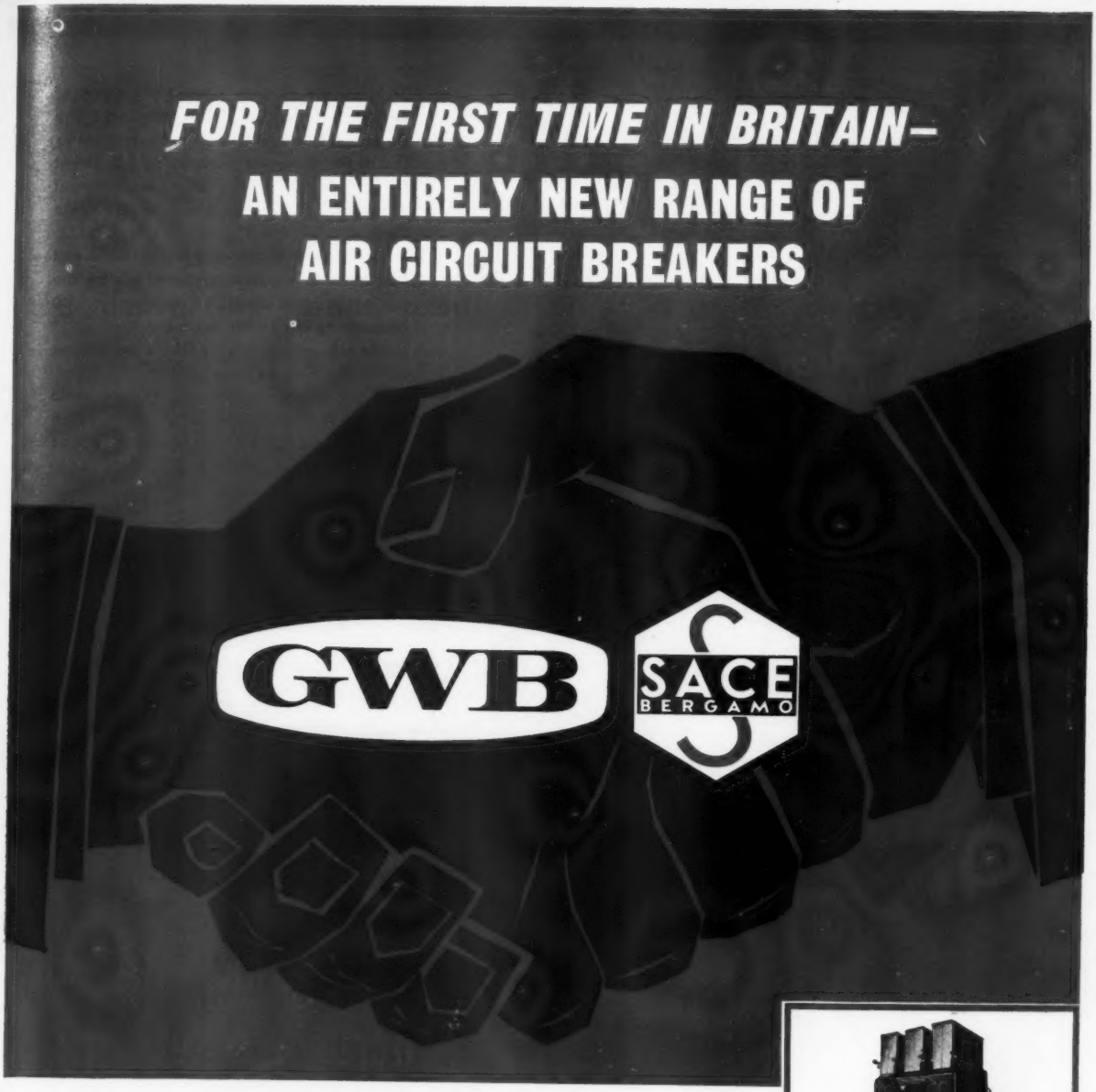
FOR THE FIRST TIME IN BRITAIN–
AN ENTIRELY NEW RANGE OF AIR CIRCUIT BREAKERS



An agreement has been concluded whereby the Control Gear Division of G.W.B. has been appointed sole licencees in Great Britain for the complete range of Automatic Air Circuit Breakers manufactured by SACE of Bergamo, Italy.

Small and compact, and with an extremely high making and breaking capacity, these offer many advantages over breakers available so far. Ranging from 60 amps to 4,000 amps in 2 pole, 3 pole and 4 pole designs, they are fully tested and approved for industrial and marine use.

Various methods of mounting, e.g. plug-in, surface or flush, front or back connected are available to suit individual requirements, together with a comprehensive range of ancillary fitments. Full details will be sent on request.

GWB
CONTROL GEAR

CONTROL GEAR DIVISION G.W.B. FURNACES LIMITED
DUDLEY · WORCESTERSHIRE · TELEPHONE: DUDLEY 55455

Associated with Gibbons Bros. Ltd. and Wild-Barfield Electric Furnaces Ltd.

Type Z 630-600 amp air circuit breaker having a K.E.M.A. certified breaking capacity of 20 KA at 500 volts AC. (equivalent to 15 MVA at 415 V.A.C.)

Section of a typical L.V. Distribution Switchboard using Z 630 Draw-out pattern air circuit breakers in multi-tier formation.

GWB/S/301

The General Electric Company Limited of England has been awarded the contract by the Compânia Nacional de Teléfonos del Peru to supply the radio and multiplexing equipment for a microwave system linking the towns of Arequipa, Lima, Trujillo, Chiclayo and Piura in Peru.

The network comprising five terminal and twenty-seven repeater stations will be the longest in South America extending for 1,100 miles along the Pacific seaboard.

The network will employ GEC's well proven 2000Mc/s radio relay equipment.

A main and standby (protection) radio frequency channel will be provided on all routes. In the event of failure or degradation of the working radio channel changeover to the standby is automatic.

Each radio channel has a capacity of 240 speech channels.

G.E.C. provides nationwide microwave network in Peru

For further information on the radio and multiplexing equipment, please write for Standard Specifications SPO.5502 and SPO.1370.

G.E.C.

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Transmission Division

THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND

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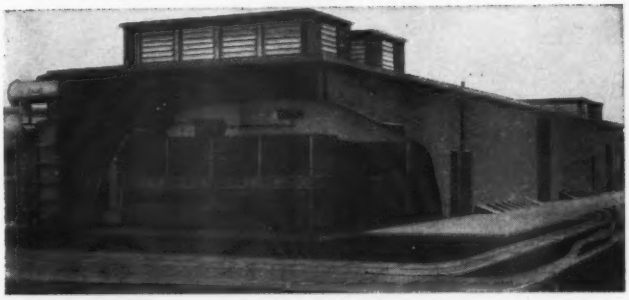
IN TRACTION SERVICE IN 18 COUNTRIES ... Hewittic RECTIFIERS

the converting plant used by the World's principal railways

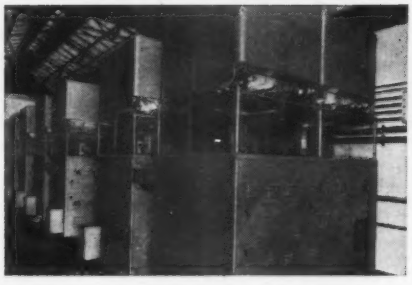


BRITISH RAILWAYS SOUTHERN REGION

One of 28 substations equipped with Hewittic Rectifiers by the British Transport Commission for the Southern Region of British Railways. The photograph shows Wimbledon substation with one wall cut away to show the two 2,500 kW rectifiers in this half of the building.

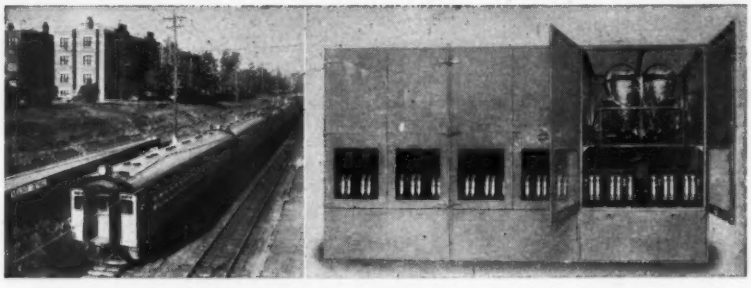
BRITISH RAILWAYS LONDON MIDLAND REGION

A train passing one of the 14 Hewittic Rectifier substations on the Liverpool-Southport line. These have an aggregate capacity of 24,260 kW and supply 93 miles of electrified track. Hewittic Rectifiers installed on other sections of this region total 47,300 kW



LONDON TRANSPORT RAILWAYS

The 4,000 kW Bond Street substation, equipped exclusively with Hewittic Rectifiers. The plant comprises four 1,000 kW combined rectifier and enclosed air-cooled transformer units. This company is also responsible for the supply and installation of all A.C. and D.C. control gear. Some 90,000 kW of Hewittic Rectifiers have been supplied to the London Transport Executive.



CANADIAN NATIONAL RAILWAYS

The electrified section of the Canadian National Railways, comprising some 70 track miles in the vicinity of Montreal Terminal, is supplied with D.C. by Hewittic Rectifiers in two 3,000 kW substations at Central Station and Saraguay. The photographs show left, a train leaving Mount Royal Station, and right, one of the four 1,500 kW equipments in service. These are designed for operation at 3,000 volts, D.C.

* Send for Publication R200/4

HACKBRIDGE AND HEWITTIC ELECTRIC CO., LIMITED
WALTON-ON-THAMES - SURREY - ENGLAND
Telephone: Walton-on-Thames 28833 (8 lines) Telegrams & Cables: "Electric, Walton-on-Thames"

Assembling a submersible motor.

Here, there and everywhere throughout the world Harland have an unequalled reputation for the design and construction of pumping plant for every requirement. Specialisation in hydraulic, electrical and control engineering is the basis of Harland's interest in all pumping installations from the simple to the most complicated and complex project.

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A191/14

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are designed for long life and trouble-free service, but it is re-assuring to know that provision is made to gain quick and easy access to the interior for the inspection of any part of a machine.

Vertical and horizontal A.C. and D.C. motors of all types are designed to suit individual power applications up to 5,000 h.p.

A.C. and D.C. control gear can be supplied to suit individual requirements.

We invite your enquiries

Allen electrical equipment is backed by well over 75 years' specialised design and manufacturing experience.

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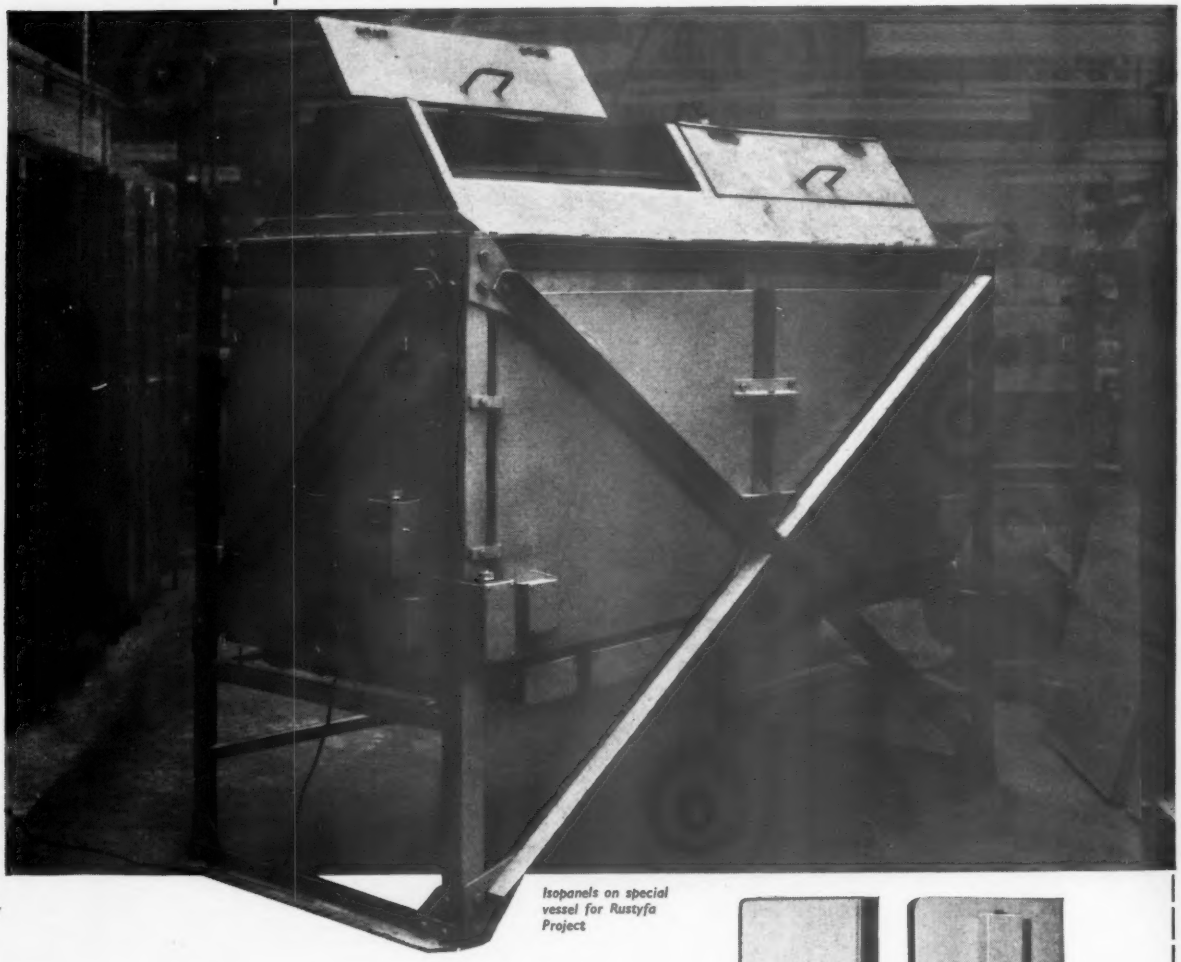

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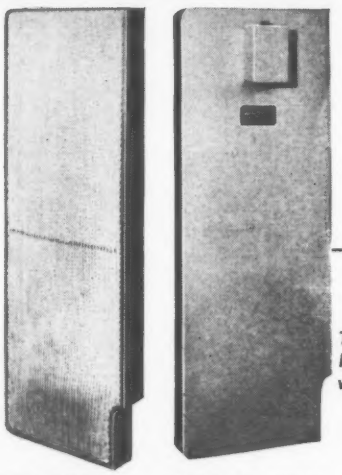

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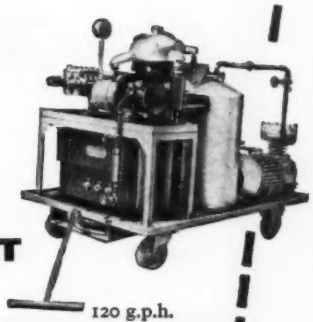

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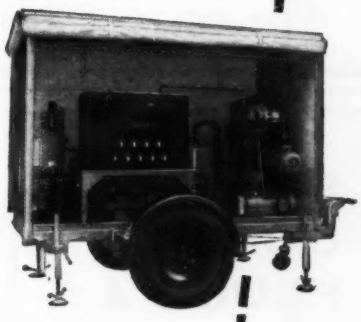
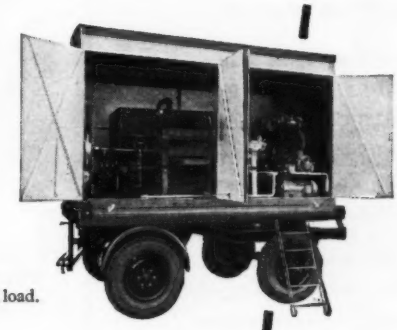


800 g.p.h.



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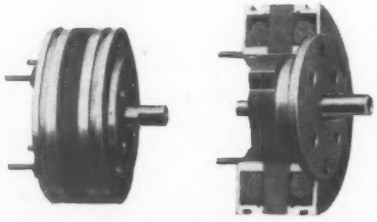

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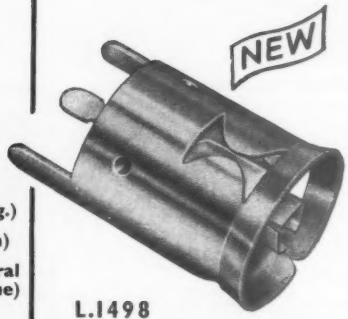

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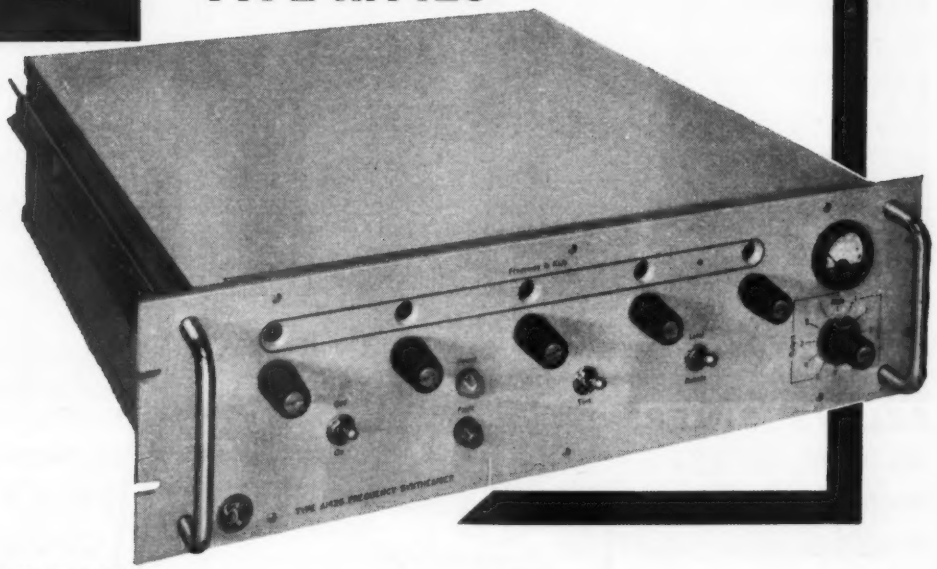

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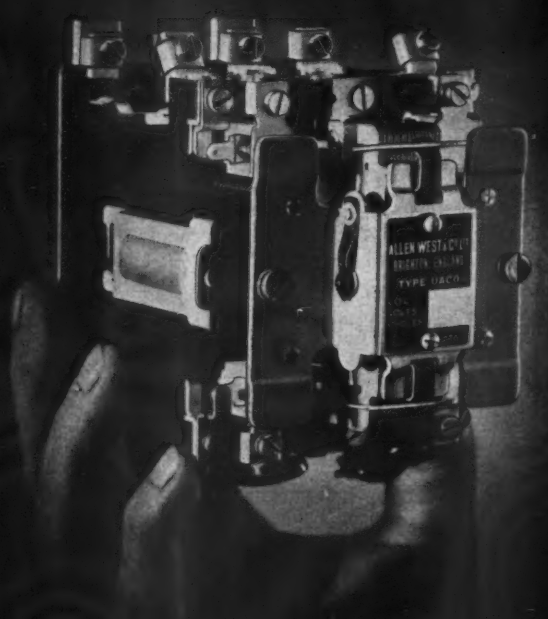

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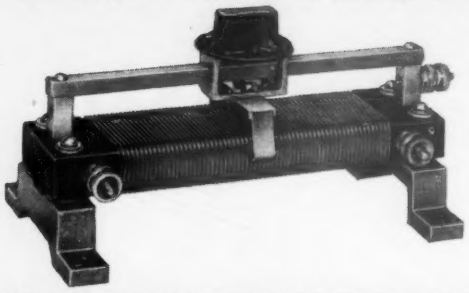

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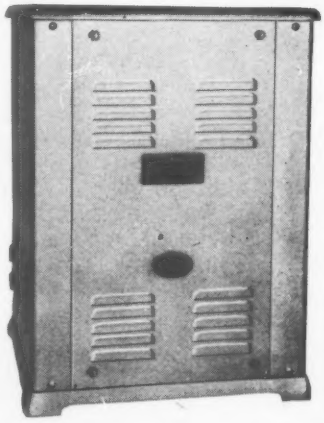

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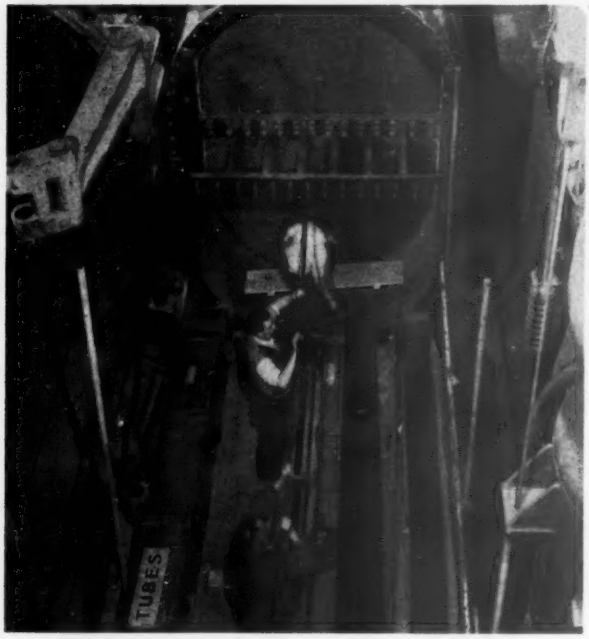

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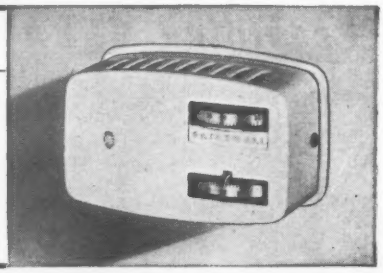
Bimetal elements are ideal for use in the manufacture of thermometers, control elements for air conditioners, ventilators, water mixers, valves, driers, ovens, domestic irons, immersion heaters, radiators, thermostats, fire alarms, etc.

Table giving the properties of the more important types of Telcon Thermostatic Bimetals.

Type	*Strip Deflection Constant	Electrical resistivity Microhm-cm at 20°C	Range of max. Sensitivity °C	Useful deflection Range °C	Stabilising Heat Treatment Temp. °C for One hour
140	14.0 x 10-6	76	20-200	-70 to 350	350
400	12.0 x 10-6	70	70-310	-70 to 400	350
15	9.5 x 10-6	17	20-150	-70 to 250	350
75	6.8 x 10-6	57	150-325	-70 to 400	350
38	3.8 x 10-6	56	20-250	-70 to 300	350
188	9.0 x 10-6	93	10-150	-70 to 400	350
131	13.3 x 10-6	18	10-130	-75 to 170	175
11	8.4 x 10-6	20	10-150	-70 to 260	350
200	19.9 x 10-6	109	10-175	-75 to 160	260



*The deflection constant is defined as the deflection of a strip of unit length and unit thickness for each °C rise in temperature over the linear part of the deflection curve.

All types of Bimetal shown in the table are manufactured in strip form down to 0.005 in. thick, in widths not greater than 6 in. They can also be supplied down to 0.0025 in. thick with a maximum strip width of 3 in. Cut strips are also supplied. Materials can be suitably etched to indicate the high or low expansion sides, as requested.

enquiries to: **TELCON METALS LTD.**

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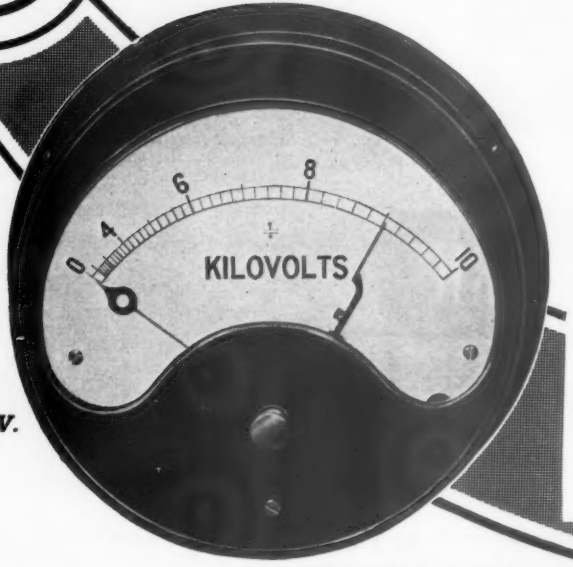

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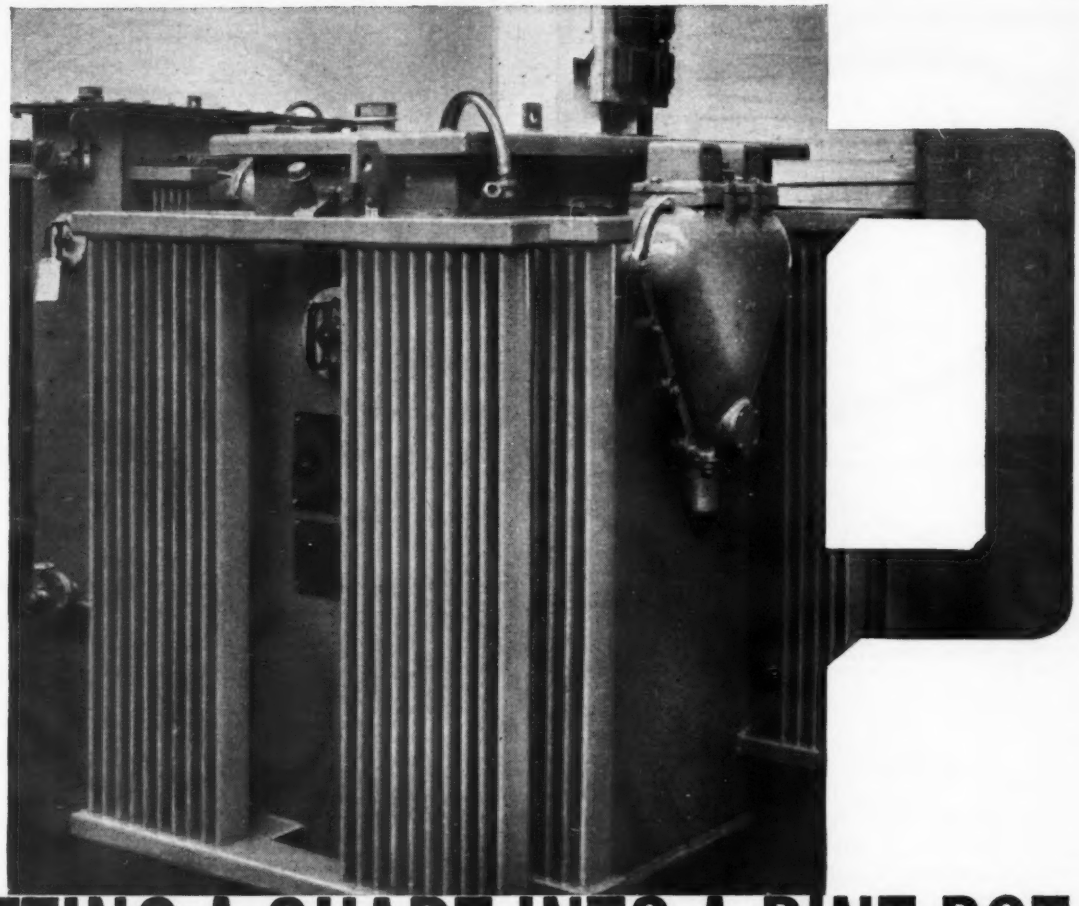

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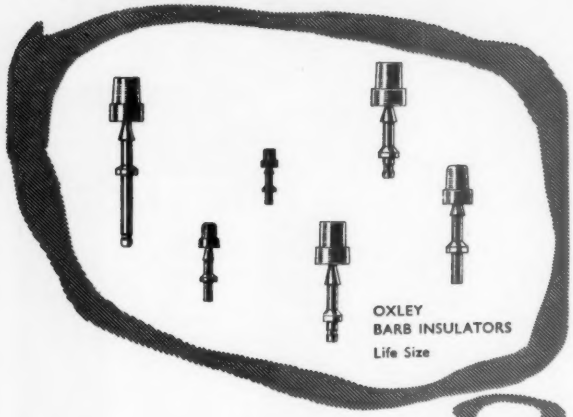

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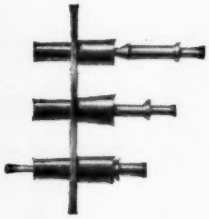

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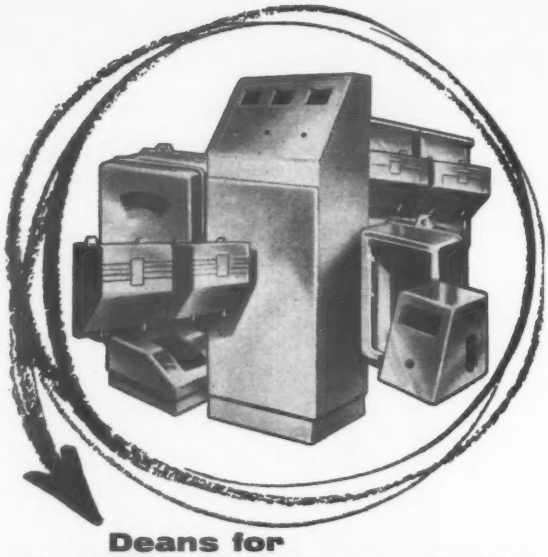

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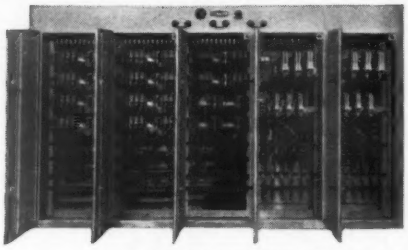

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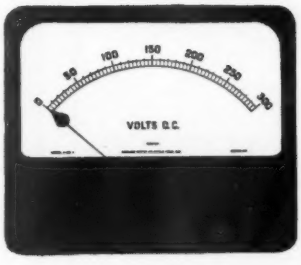

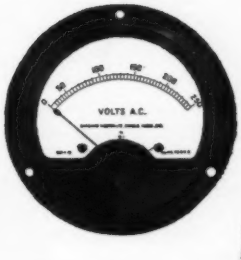

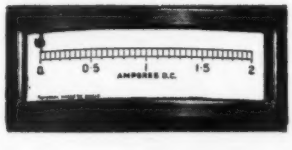

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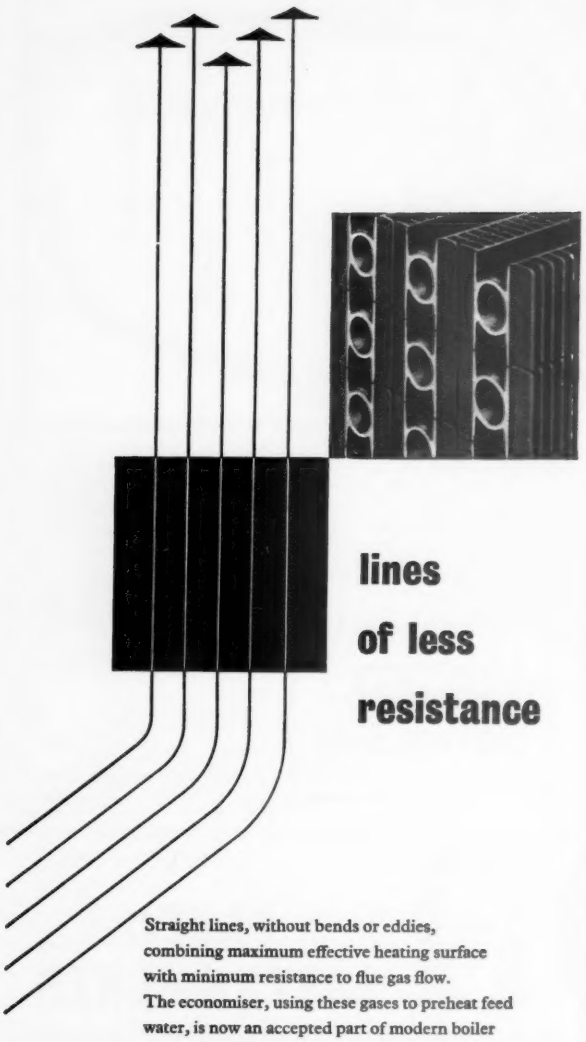

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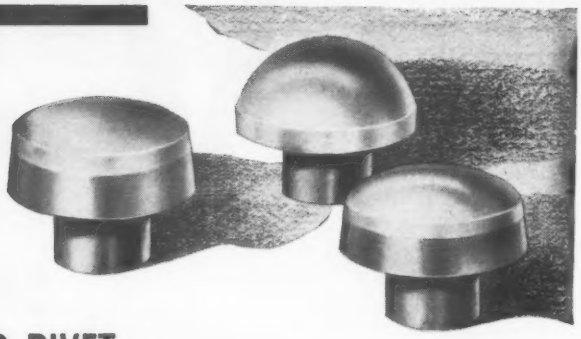

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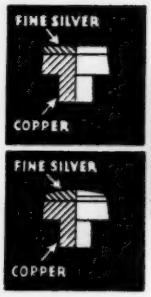

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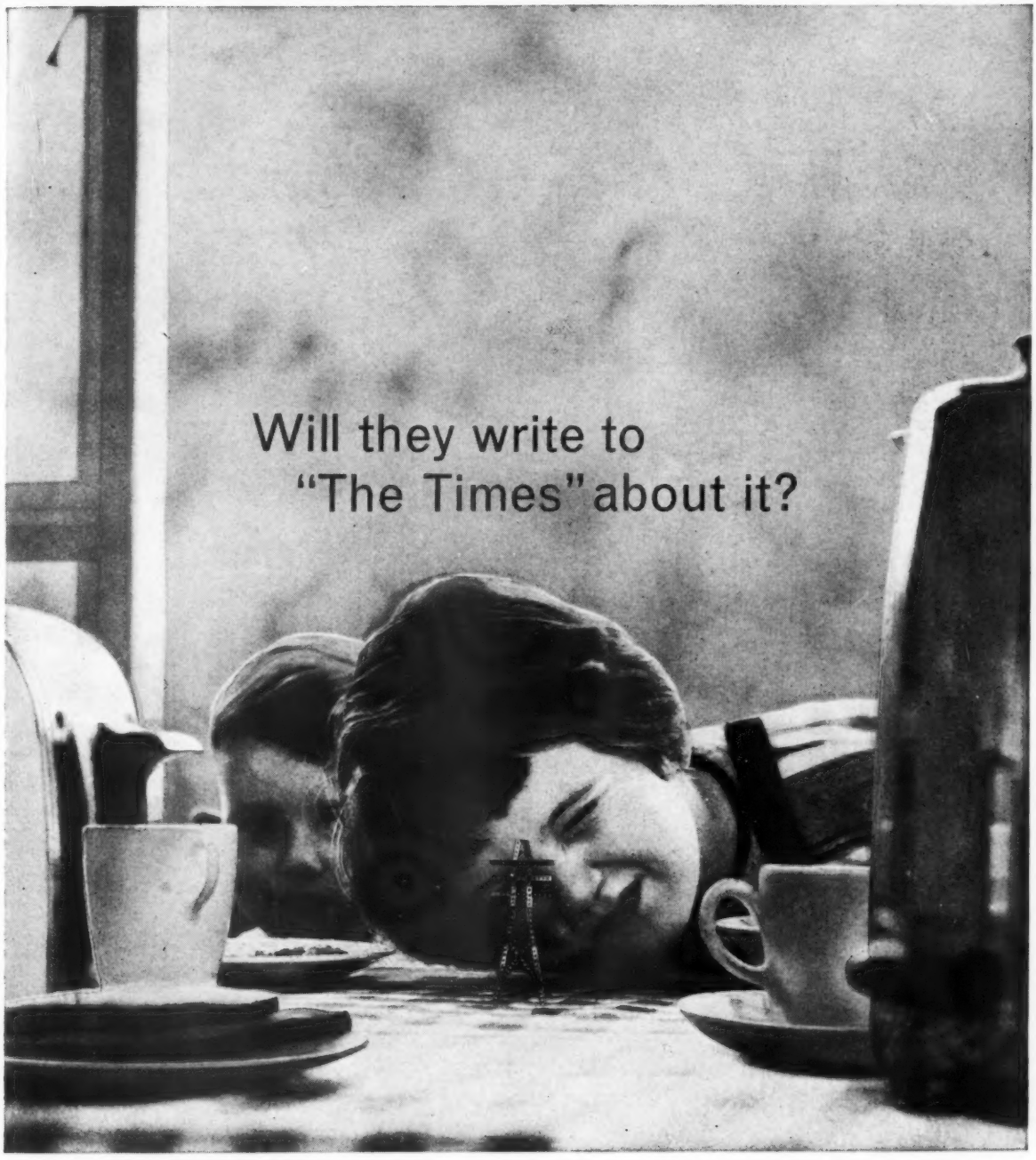

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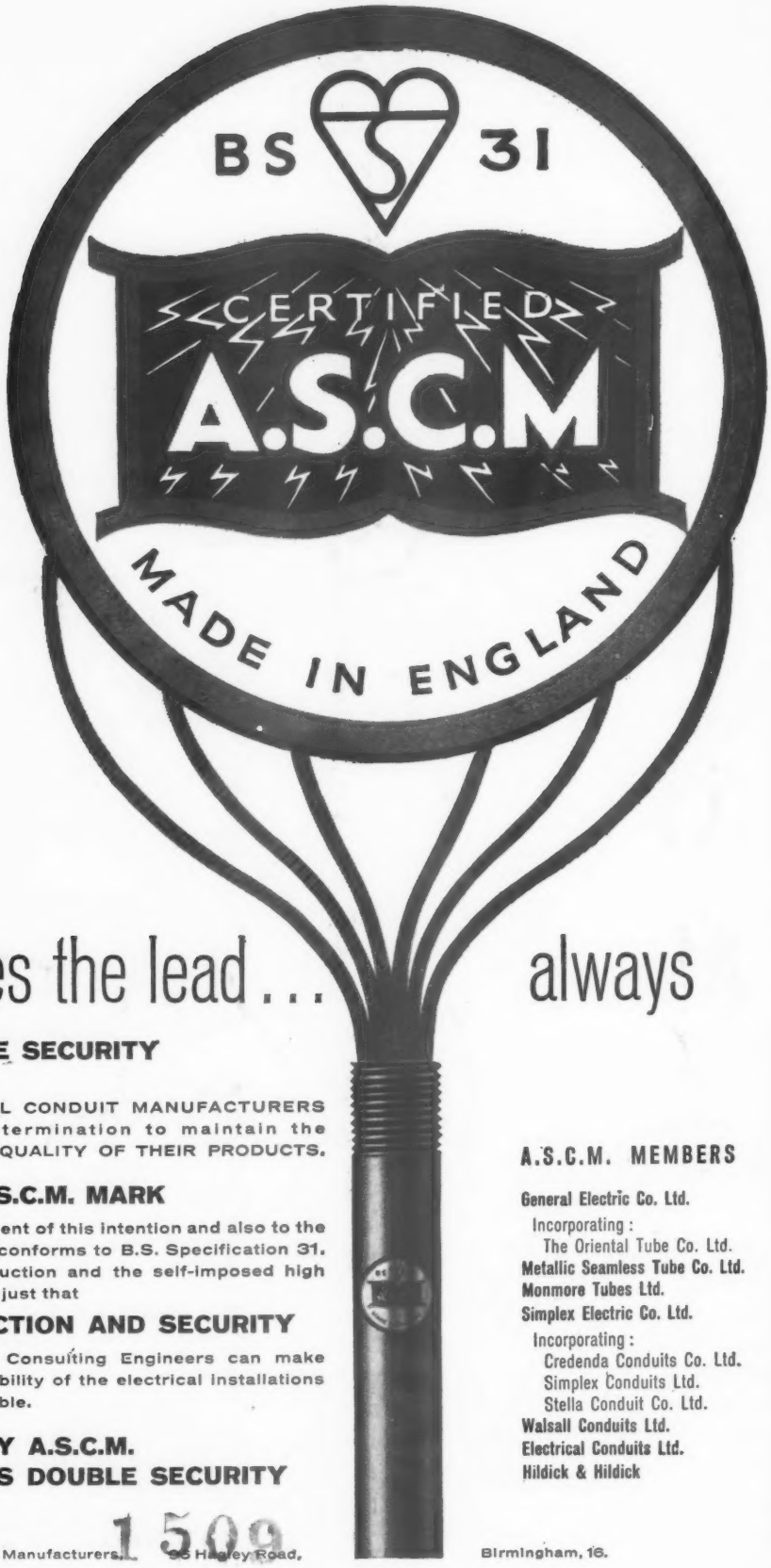

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